PROCEEDINGS

OF THE

AMERICAN PHILOSOPHICAL SOCIETY.

HELD AT PHILADELPHIA, FOR PROMOTING USEFUL KNOWLEDGE.

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NOTE.—As inquiries have been received respecting Plates Nos. 1, 6, 7 and 8, of Vol. XI., Proceedings of the American Philosophical Society, Correspondents and members of the Society are hereby informed, that the plates of that Volume were irregularly numbered, and that no plates corresponding to the above mentioned numbers were printed.

Stated Meeting, Aug. 18th, 1871.

Present, two members.

Secretary, MR. TREGO, in the chair.

Photographs were received from Prof. Max Müller, of Oxford, England, and from M. Stanislaus Julien, Membre de l' Institut, Paris.

A letter accepting membership was received from Prof. Cleveland Abbe, dated Washington, D. C., July 24, 1871.

Letters of acknowledgment were received from the New York City University (86).

Donations for the library were received from the Hungarian Academy; Herr K. Magey; the Society at Moscow; the Russian Academy; Prussian Academy; Geological Society and Botanical Society of Berlin; the Societies at Gottingen and Bremen; the Geographical Society at Paris; the London Astronomical Society and Meteorological Bureau; Editors of Nature, Cornwell Polytechnical Society; Peabody Museum; Essex Institute; Medical News; and U. S. Department of Engineers at Washington.

The death of Mr. Sidney G. Fisher, a member of the Society, at his residence near Rising Sun, Philadelphia, July 25th, 1871, in the 63d year of his age, was announced.

Mr. Chase presented some tables of daily Rainfalls at the Observatorio do Infante Don Luiz, Lisbon, from 1855 to 1870, with some comparisons, indicating an opposition between the lunar daily rains at Lisbon and Philadelphia, similar to the one he had pointed out as existing between the solar daily rains at the same stations.

And the meeting was adjourned.

Stated Meeting Sept. 15th, 1871.

Present, two members.

Vice-President, MR. FRALEY, in the chair.

A letter accepting membership was received from Mr. B. C. Tilghman, dated Philadelphia, Aug. 1871.

Photographs for the Album were received from Prof. Geo.

H. Cook and Col. M. J. Cohen, the latter sending a carte de visite of the late Dr. Joseph I. Cohen, of Baltimore.

Letters of envoi were received from the Central Observatory of Russia, and the office of the Chief of the U. S. Engineers at Washington.

Letters acknowledging the receipt of Publications of the Society were received from the Russian Central Observatory; the Leeds P. & L. Society, August 24 (xiv. i. 83, 84, 85,); the Society of Antiquaries, London, August 26 (xiv. i. 83, 85); the Society of Arts at Batavia, May 31, 1869 (xiii. 2, Proc. July, 1865); the Radcliffe Observatory, August 10th, (83, 84, 85); the Geological Committee of Italy, at Florence, August 12 (Proc. vol. xi. 2); the Glasgow Philosophical Society, August 10th (83, 84, 85); the Regents of the New York University, August 7 (Proc. vol. x, xi); the Boston Public Library, August 23 (86); Rhode Island Society for the encouragement of Domestic Industry (86); Georgia Historical Society, Savannah, August 24 (86); Wisconsin Historical Society, Madison, August 25 (86); New York Historical Society, New York, September 1 (86); New Jersey Historical Society, Newark, Sept. 1 (86); Essex Institute, Salem, Mass., Sept. 2, 1871 (86).

Donations for the Library were received from the Academies at St. Petersburg, Berlin and Bruxelles; the Societies at Batavia and Riga; Herr Von Frauenfield, of Vienna; the Geological Committee of Italy; Geographical Society in Paris; Zoological Society and Society of Antiquarians in London; London Nature; the Essex Institute; Boston Natural History Society; R. I. Society for the Encouragement of Domestic Industry, at Providence; the American Journal of Science; Mr. J. H. Trumbull; the American Chemist; President Barnard of Columbia College; the Franklin Institute; American Journal Medical Science; Journal of Pharmacy; Penn Monthly; and Dr. Richard J. Dunglison, of Philadelphia.

A communication for the Proceedings was received, entitled "On the Formation and Primitive Structure of the Solar System," by Professor Daniel Kirkwood, of Bloomington, Indiana.

And the meeting was adjourned.

On the Formation and Primitive Structure of the Solar System.

By Professor Daniel Kirkwood.

(*Read before the American Philosophical Society, Oct.* 6, 1871.)

The development of any branch of science is generally a slow and gradual process. The obvious truths which suggested to Laplace his celebrated hypothesis of the solar system had been for ages well known to astronomers; but, as in the case of the earlier geological observations, they had been regarded, without any just reason, as *ultimate facts*. So now we have numerous results of observation in regard to the rings of Saturn, the zone of asteroids, the relative distances of the planets, &c., the study of which, it is believed, may lead to new and important discoveries. "These hieroglyphics older than the Nile," pointing back to the epochs at which the planets were born, will doubtless in the future be more or less clearly deciphered, and the ancient history of the solar system at least partially developed.

It is a very remarkable fact in regard to the systems of both primary and secondary planets that the periods, without any exception, have very simple relations of approximate commensurability. This truth, though obvious on mere inspection, seems not to have attracted the special notice of astronomers, as no attempt had been made, previous to that of the writer, to assign its physical cause. A general view of these approximations is presented in the following tables, where the periods of the primary planets, Mercury, Venus, &c., are represented by P^{I}, P^{II}, &c., and those of the satellites by p^{I}, p^{II}, &c.

I.

The Primary System.

$\frac{1}{2}P^{VIII} = 82.37$ years $= P^{VII} - 1.65$ y.

$\frac{1}{3}P^{VII} = 28.01$ " $= P^{VI} - 1.45$

$\frac{2}{5}P^{VI} = 11.78$ " $= P^{V} - 0.08$

$\frac{1}{6}P^{V} = 1.97$ " $= P^{IV} + 0.09$

$\frac{1}{12}P^{V} = 0.988$ " $= P^{III} - 0.012$

$\frac{2}{3}P^{III} = 0.667$ " $= P^{II} + 0.052$

$\frac{2}{5}P^{II} = 0.246$ " $= P^{I} - 0.005$

II.

The Jovian System.

$\frac{2}{7}p^{IV} = p^{III} - 3^{m}9^{s}$

$\frac{1}{2}p^{III} = p^{II} + 36\ 40$

$\frac{1}{2}p^{II} = p^{I} + 9\ 45$

III.

THE SATURNIAN SYSTEM.

$$\tfrac{2}{7}p^{VIII} - p^{VII} + (?)$$

$$\tfrac{1}{8}p^{VIII} - p^{VI} - 1^h\ 54^m\ 41^s$$

$$\tfrac{2}{7}p^{VI} - p^{V} + 0\ 55\ 13$$

$$\tfrac{1}{8}p^{VI} - p^{IV} - 1\ 54\ 15$$

$$\tfrac{1}{2}p^{IV} - p^{II} - 0\ 2\ 33$$

$$\tfrac{1}{2}p^{III} - p^{I} + 0\ 1\ 50$$

IV.

THE URANIAN SYSTEM.

$$\tfrac{2}{3}p^{IV} - p^{III} + 6^h$$

$$\tfrac{1}{2}p^{III} - p^{II} + 5$$

$$\tfrac{2}{3}p^{II} - p^{I} - 1$$

It is infinitely improbable that all these coincidences should be purely accidental. Their physical cause is a legitimate object of research, and the writer is vain enough to believe that he has suggested the true one.* Before proceeding with our discussion, however, it may be proper to indicate such modifications of the nebular hypothesis as seem to be demanded by recent discoveries.

The view generally received in regard to the formation of the solar system has been that equatorial rings were abandoned *only* in the vicinity of the present planetary orbits. As the writer has elsewhere observed, however, "it seems highly probable that, after first reaching the point at which gravity was counterbalanced by the centrifugal force arising from the rotation of the contracting spheroid, a continuous succession of narrow rings would be thrown off in close proximity to each other, and revolving in different periods according to Kepler's third law." But in this matter we are not left to mere speculation. The zone of minor planets has evidently not been produced by a single annulus, all the parts of which had, at first, nearly equal velocities. On the contrary, it must have resulted from an almost continuous abandonment of narrow rings, from the exterior limit at the mean distance 3.50, down to the interior, at 2.20. The rings of Saturn, moreover, afford a similar index to the process of planetary formation.

Let us assume, then, the existence of a central mass S, with a ring R, and an exterior planet P. The particles of the ring having different distances from the centre of motion will move with different velocities. Let

*Met. Astr., Ch. XIII., and Monthly Notices of the R. A. S., vol. XXIX.

S p be the distance at which a planetary molecule would revolve in one half the period of the planet P. The disturbing effect of P will render the orbit of p more and more eccentric. The particle, therefore, must be brought into contact, either in aphelion or perihelion, with other parts of the ring, thus forming a planetary nucleus at such distance that its period would be *nearly* one-half that of the exterior planet. Similar reasoning will apply to the distances at which the ratio of the periods would be $\frac{1}{3}$, $\frac{2}{5}$, or any simple relation of commensurability. We have thus an extremely simple explanation of the facts embodied in the preceding tables. Should it be objected that this theory fails to account for the formation of the most remote planet, it may be answered that the first separation of matter from the condensing nebula probably occurred before the mass had assumed a symmetrical form. The successive ratios of the periods from Neptune to Jupiter are $\frac{1}{2}$, $\frac{1}{3}$ and $\frac{2}{5}$. With Jupiter, "the giant of the solar system," the process of planet formation seems to have culminated; the mass of this stupendous globe being nearly three times greater than that of all other members of the solar family united. But why have we no planet of any considerable magnitude whose period is one-half, one-third, or two-fifths that of Jupiter? It may be answered, in the first place, that the matter of asteroid ring was so extremely rare that the intersection of orbits failed to produce large planetary nuclei. The question recurs, however, whence the *small mass* of the ring immediately interior to the *largest* member of the system? The circumstances of the primitive asteroid-ring were different from those of any other. As its successive portions were thrown off at the equator of the solar nebula they would be liable to great perturbations by Jupiter. The perihelion distance of portions of the zone might thus become less than the equatorial radius of the spheroid by which they had been abandoned. A considerable proportion of the matter originally separated may have been thus re-united to the parent mass.*

The writer has shown however, that in the distribution of the mean distances of the asteroids, we have indications of an order similar to that of the exterior planets. This fact is rendered still more conspicuous by recent discoveries. The distances at which the periods of asteroids would be one-half, two-fifths, and one-third that of Jupiter, are respectively, 3.2776, 2.8245, and 2.5012. Between the mean distances 3.22 and 3.32 no asteroid has yet been discovered; while between 3.12 and 3.22 there are no less than 12. Between 2.78 and 2.88, the interval containing the distance at which five times the period of a planet would be equal to twice that of Jupiter, only two have been detected; while in the equal space immediately interior, from 2.68 to 2.78, there are 21. Finally, between 2.45 and 2.55, the space in the middle of which an asteroid's period would be one-third that of Jupiter, the number of known asteroids is 4; while in the equal space immediately interior there are 20, and in that exterior, 15. These facts are certainly very remarkable, and deserve the earnest consideration of astronomers.

*See Proc. Am. Phil. Soc., Aug. 19, 1870.

The preceding table of the primary system seems to indicate the dependence of the periods of Mars and the earth on the powerful mass of Jupiter. The relations expressed between the periods of the earth, Venus, and Mercury are sufficiently obvious. It is worthy of remark that the *original* distances of the exterior planets have been, in all probability, sensibly diminished. While the solar nebula was undergoing the process of condensation all cometary and meteoric matter attracted towards its centre, would, if the perihelion distance were considerably less than the radius of the nebula, become incorporated with the central body. This growth of the solar mass would produce a shortening of the periodic times of all planets previously formed.

The approximations to commensurability in the secondary systems are still more striking, and must produce the impression in every inquiring mind that they are not without their physical significance.

The rings of Saturn formerly supposed to be solid and continuous, are now regarded as consisting of an indefinite number of extremely small satellites. They are, in short, a compact cluster of secondary asteroids, analogous to the primary zone between Mars and Jupiter. In the latter, it is true, a large proportion of the primitive matter has collected in distinct, planetary masses; while a similar result has been prevented in the Saturnian rings by their proximity to the central body. In one respect, however, we observe a striking correspondence. It has been shown that several positions occur in the asteroid zone where planetary periods would have simple relations of commensurability with the period of Jupiter, and that portions of the original ring occupying these positions would be liable to great disturbance. Now, the ring of Saturn is evidently subject to like perturbation by the nearest satellites. Hence gaps or chasms, analogous to those in the zone of asteroids, ought also to be found in the secondary ring. It has accordingly been noticed that Cassini's, or rather Ball's division occurs precisely where the periods of satellites would be commensurable with those of the four members of the system immediately exterior.*

But astronomers have sometimes seen the ring of Saturn apparently separated by several black lines into concentric annuli. At other times, however, no such divisions could be detected. The fact, therefore, of the permanence of these gaps is extremely doubtful, except in the case of a division of the exterior bright ring. This has been frequently seen by eminent astronomers; and it is probable, though not absolutely certain, that it is never entirely closed. Most observers agree in placing it outside of the middle of the exterior ring. Let us now inquire whether any simple relation of commensurability obtains between the periods of satellites revolving at the distance of this outermost gap, and those of Mimas, Enceladus, Tethys, and Dione.

$\frac{4}{7}$ of the period of Mimas	$=$	$12^h\ 56^m$
$\frac{2}{7}$ " Tethys	$=$	12 57

* *Meteoric Astronomy*, Chap. XII.

$\frac{1}{3}$	"	Dione	= 13	8
$\frac{2}{3}$	"	Enceladus	= 13	9

The interior radius of the outer ring = 1.9963

The radius of a circle bisecting the outer ring = 2.1209

The distance of a satellite whose period is $12^h\ 56^m$ = 2.1473

The distance of a satellite whose period is $13^h\ 9^m$ = 2.1510

The exterior radius of the outer ring = 2.2456

It is thus seen that just beyond the middle of the outer ring, where the division is actually found, another zone occurs in which the periodic times of satellites would be commensurable with those of Mimas, Enceladus, Tethys and Dione.

The FACTS detailed in the preceding pages are unquestionable. In regard to the proposed *explanation* of these facts the writer would speak with becoming caution. In his humble attempt to reduce a large class of isolated truths to the domain of law some important considerations may have been overlooked. Be this as it may, he indulges the hope that abler astronomers may deem the enquiry not unworthy their researches.

Stated Meeting, Oct. 6th., 1871.

Present, fifteen members.

Vice President, Mr. FRALEY, in the chair.

A photograph for the Album was received from Professor E. N. Horsford, dated Cambridge, Massachusetts, October 29.

Letters of acknowledgment were read from the London Meteorological Office, September 22 (83, 84, 85); and the Buffalo Society of Natural Sciences, December 1, 1870 (XI Pro).

Letters of envoi were received from the Natural History and Historical Union of Donauerschingen, September 15, and the United States Secretary of the Interior, Washington, D. C., September 15, 1871.

A recent letter from Mr. Carlier to Mr Durand, was read by Mr. Price, who offered a Resolution, which was adopted, authorizing the presiding officer of the meeting to execute

a Power of Attorney to M. Carlier, of Paris, to receive moneys on account of the Michaux Legacy.

Donations for the Library were received from Doctor Zenaro, of Constantinople, the Union at Donauerschingen, the Prussian and Belgian Academies, Geographical Society at Paris, Annales des Mines, Revue Politique, the Meteorological Office and Nature of London, the Montreal Natural History Society, the American Academy, Natural History Society, and Old and New of Boston; Mr. Edmund Quincy, of Dedham, Massachusetts, the American Journal of Arts and Sciences; Doctor Squibb, of New York, the Franklin Institute, College of Pharmacy, and Penn Monthly, of Philadelphia, the Census Bureau at Washington, and the Historical Society of Georgia at Savannah.

An obituary notice of the late Doctor Rhoads, of Philadelphia, was read by Doctor Henry Hartshorne.

Professor Kirkwood's paper on the Origin of the Solar System, was read by the Secretary.

A letter from Professor Cope to the Secretary, on the Reptile and Fish remains in the State Museum of Kansas, was read by the Secretary.

Mr. Baird communicated his views on the cause of the decline of vegetable vitality in fruit trees, dating from the year 1860.

Mr. Lesley read a note on some supposed Egyptian letters, in the Dolmen of Manelud, in Brittany.

New nomination, No. 679 was read, and the meeting was adjourned.

Note of some Cretaceous Vertebrata in the State Agricultural College of Kansas, U. S. A.

By Edward D. Cope.

Manhattan, Kansas, 1871.

My dear Prof. Lesley:

A visit to the State Agricultural College of Kansas at Manhattan, has enabled me to examine the cretaceous vertebrata contained in its collection. Professor B. F. Mudge, already well known by his interesting discoveries among the *Pythonomorph* reptiles and *Saurodont* Fishes, has

added to his collections by an excursion in the neighborhood of Fort Wallace, during the present summer. By his permission I have made an examination of these fossils, and find them to be of much interest. They consist of seven species of *Pythonomorpha*, and three of *Saurodontidæ*. The following are approximate or exact determinations of them.

PYTHONOMORPHA.

MOSASAURUS quite near to *M. depressus*, Cope, from New Jersey.

LIODON DYSPELOR, Cope, probably. The first time that this gigantic reptile has been discovered in Kansas.

LIODON; a large species near to *L. proriger*, Cope. It is represented by dorsal, lumbar, and caudal vertebræ, by ribs, and by bones of the extremities. The humerus is a remarkable bone having the outline of that of *Clidastes propython*, Cope, but is very much stouter, the antero-posterior dimensions of the proximal extremity being greatly enlarged. The long diameters of the two extremities are in fact nearly at right angles, instead of in the same plane, and the outline of the proximal is subtriangular, one of the angles being prolonged into a strong deltoid crest on the outer face of the bone, which extends half its length. The inner or posterior distal angle is much produced, while the distal extremity is a flat slightly curved diamond-shaped surface. The radius is as broad as long and three quarters of a disc. The phalanges are stout, thick and depressed, thus differing much from those of *Liodon ictericus*. A bone which I cannot assign to any other position than that of femur * has a peculiar form. It is a stout bone but more slender than the humerus. The shaft is contracted and subtrilateral in section. The extremities are flattened, expanded in directions transverse to each other, the proximal having, however, a lesser expansion, in the plane of the distal end. The former has, threrefore, the form of an equilateral spherical triangle, the apex enclosing a lateral fossa and representing probably the great trochanter. The distal extremity is a transverse and convex oval.

	M.
Length humerus	0.10
Proximal diameter do	.095
Length femur	.08
Proximal diameter do	.065
Median "	.035
Length centrum dorsal vertebra without ball	.061
Transverse diameter cup	.06
Vertical "	.053

LIODON LATISPINUS, Cope, sp. nov.

This is a large species, nearly equalling the *L. mitchillii* in its dimensions, that is forty or fifty feet in length. The remains representing it consist of seven cervical and dorsal vertebræ, five of them being continuous and enclosed in a clay concretion.

* Prof. O. C, Marsh has discovered the posterior limbs in this genus and *Clidastes* but has as yet published no description of them. See Sillim, Journ. 1871, p. 448.

These display the elongate character seen in *L. laevis*, etc., but the articular surfaces are transversely oval, thus resembling the *L. ictericus*. They are less depressed than in *L. perlatus* and *L. dyspelor*. The cup and ball of the penultimate cervical rise a little more transverse than those of the fourth dorsal. The last cervical is strongly keeled on the middle line below, and with a short obtuse hypopophysis marking the beginning of the posterior third of the length; the median line of the first dorsal has an obtuse ridge. There is no keel on the fourth dorsal. The diapophyses on the last two cervical and three first dorsal vertebræ have great vertical extent; the articular surface for the rib is not bent at right angles on the last cervical. Neural arches and spines are well preserved in most of the specimens. There is no trace of zygantrum. The neural spines are flat, and have considerable antero-posterior extent on cervical as well as dorsal vertebræ, and are truncate above. The first dorsal has a long strong rib.

	M.
Transverse diameter cup penultimate cervical vertebra	.051
Vertical diameter of same	.041
Length centrum fourth dorsal, without ball	.072
Vertical diameter ball	.0455
Transverse do	.0555
Elevation front margin neural spine penultimate cervical	.088
Antero-posterior diameter do do do	.05

There are smooth bands around the balls and the surfaces of the centra are striate to these.

The depressed cups of the cervicals and anterior dorsals distinguish this species from the *L. validus*, *L. proriger* and *L. mudgii*. The same elements are much larger and more elongate than in *L. ictericus*.

LIODON, sp. near *ictericus*, Cope.

Represented in Prof. Mudge's collection by portions of cranium including jaws and quadrate bones, etc., with cervical and dorsal vertebræ.

CLIDASTES VYMANII, Marsh, probably.

CLIDASTES CINERIARUM, Cope. Dorsal and cervical vertebræ.

SAURODONTIDÆ.

ICHTHYODECTES, nr. *ctenodon*, Cope.

ANOGMIUS CONTRACTUS, gen. et sp. nov.? Saurodontidarum.

Represented by a large series of vertebræ and portions of fins of an individual of perhaps four feet in length. The characters of the vertebræ are those of *Ichthyodectes* in part, i. e. they lack the lateral grooves, but they resemble those of *Saurocephalus* in having the basal elements of the neural and haemal elements inserted by gomphosis and not coössified with the centrum. Specifically, the centra are relatively longer than in *I. ctenodon*, and more as in the shorter forms of *Saurocephalus*, as *S. prognathus*, which species the present one approaches in size.

SAUROCEPHALUS, nr. *prognathus*, Cope.

Obituary Notice of Edward Rhoads, M. D.

By Henry Hartshorne, M. D.

(*Read before the American Philosophical Society, Phila. Oct.* 6, 1871.)

Of those recently deceased, members of a profession which has contributed a large share of workers to the different fields of biological science, few have given greater promise, and not many among us have attained to better performance in a short career, than Edward Rhoads. Unfavorable for the full appreciation of his work, except by those with whom he was closely associated, has been the fact that much of it has been unrecorded; being the daily labor of the practitioner and teacher of medicine. But it is fitting that this Society, whose pursuits and membership are not narrowly limited, should at least briefly record its recognition of such high ability and character.

Edward Rhoads was born in Philadelphia, September 29, 1841. After a good preliminary training, in which an early love of natural science displayed itself, he entered Haverford College in 1855; and was graduated there, at the head of his class, in 1859. The rural situation of the college afforded him an opportunity for the study of Botany, in which he became well versed while a sudent. Shortly after leaving college, an attack of rheumatic fever, involving the heart, began those inroads upon his constitution, the repetition of which afterwards abridged his life. In the fall of 1860 he commenced the study of medicine, and obtained the degree of Doctor of Medicine at the University of Pennsylvania, in 1863. He was then elected, after a competitive examination, Resident Physician in the Philadelphia Hospital, West Philadelphia. This was followed, in 1864, by his appointment as Resident Physician in the Pennsylvania Hospital. In the midst of his arduous duties there, performed with distinguished success and with satisfaction to all, he was again affected with articular rheumatism, which renewed seriously the disorganizing disease of his heart.

On recovering from this attack, he visited Europe, in 1865, being absent eight months. In 1866, he was appointed Visiting Physician to the Philadelphia Hospital; where his professional talent, enthusiam and knowledge, and his capacity as a clinical teacher, found free scope for development and utility. He was at the same time assiduously engaged in private medical teaching, as an examiner in connection with the courses of the University of Pennsylvania, and in giving lectures upon medical chemistry and connected subjects. In 1870 the faculty of the University appointed him its lecturer on Physical Diagnosis. His first course of lectures was interrupted by illness, which prevented his ever resuming the duties of a public instructor.

In the same year, a number of gentlemen proposing to establish a new medical journal,—The Philadelphia Medical Times,—its editorship was unanimously offered to Dr. Rhoads. This duty, which enlisted all his zeal, and would have illustrated admirably his professional learning and

tact, he was obliged to forego on account of his failure in health, which, after great suffering for several months, ended his life January 15, 1871.

In private practice, Dr. Rhoads was rapidly gaining the confidence and success which his skill and acquirement deserved; as well as the warm and grateful attachment of many families,—which remains in commemoration of his virtues, more faithful than any eulogy, and more enduring than any monument. He was elected to membership, besides the Philosophical Society, in the Philadelphia College of Physicians, of which he was Recording Secretary, the Academy of Natural Sciences, and the Pathological Society. To the proceedings of the latter he contributed a number of papers. He wrote for the American Journal of the Medical Sciences several reviews, showing a quick critical apprehension, a large acquaintance with medical science and literature, and an excellent command of language. He assisted Dr. J. F. Meigs in the preparation of an elaborate paper, published in the first volume of the Pennsylvania Hospital Reports, 1868, on "The Morphological Changes of the Blood in Malarial Fever." With Dr. W. Pepper, he contributed to the same volume the results of an extended inquiry into the "Fluorescence of the Tissues of the Human Body, especially in connection with Malarial disease and the action of Quinia." The scientific spirit which animated all his professional labors, and which he brought to the investigation of the great problems of Pathology and therapeutics, thus elevating the vocation of the physician far above routine, was well exemplified in this paper. Its preparation was suggested by the remarkable observation of Bence Jones, by whom a fluorescence resembling closely that of a solution of quinine was found to occur in solutions of the tissues of animals which had taken none of that substance. A peculiar fluorescent organic principle was here inferred to be a normal constituent of the animal body; and to this Bence Jones applied the name of "Animal Quinoidine." It was not an irrational hypothesis, that the systemic effects of the malarial poison may be attended by an injurious deficiency of this material; and that quinine, or the other extractives of Peruvian bark, may be remedial for the disease, by supplying the system with its equivalent.

Drs. Rhoads and Pepper undertook first, to ascertain whether, by chemical and spectroscopic analysis, there could be shown to be a marked diminution in the amount of animal quinoidine in the body under the influence of malarial disease. They also gave attention to the effect upon the animal fluorescence produced by the treatment of the attack by sulphate of cinchonia. The interesting result was arrived at by a series of careful and exact determinations, that there is, uniformly, a close connection between malarial disease and the diminution of "animal quinoidine;" and that this connection is apparent, not only in the presence of a fully developed paroxysm of fever, but also when the system is more insidiously, though often very seriously, affected by the morbid cause.

The same exact inquiry into evidence, with the aim to discover and establish truth, was applied by Dr. Rhoads in his consideration, both theo-

retical and practical, of the highest topics, not only of science, but of philosophy. Contented to accept no truth upon the evidence of mere tradition or human authority, his opinions upon religious subjects, being those held by the Society of Friends of which he was a member, were the result of deliberate and strong conviction. His fine critical faculty was brought to bear upon the recent Biblical and anti-Biblical controversies, represented, upon the one side, in different modes, by Strauss, Bauer, Comte, Renan and Buckle. In several essays, prepared for special occasions, only one of which, however, has been published, he displayed a calm mastery of these topics, an amount of knowledge and force of argument, such as might be looked for rather in a professed theologian than in an active member of the medical profession.

With all who knew Dr. Edward Rhoads, however, his intellectual endowments, though great, were always perceived to be subordinated to moral qualities more rare and admirable. From early youth, purity of life, unselfishness, refinement and elevation of mind, were his marked characteristics. Few examples so spotless are met with in any profession or sphere of life. In the large assembly which met at his funeral, words spoken by several who knew him well, and whose standard of character was high, were such as might fulfil the aspirations of the most saintly of men, and which very few, indeed, could deserve.

Stated Meeting, Oct. 20, 1871.

Present, nine members.

Curator, Dr. Carson, in the chair.

A letter, acknowledging receipt of No. 86 proceedings, was received from the University of the City of New York.

Donations for the Library were received from the Revue Politique; the Astronomer Royal of England; the Editors of Nature; the R. Institute of Cornwall; Thomas P. James, Esq; the Editor of the Old and New; the American Chemist; American Journal of Medical Sciences, and Medical News and Library.

A letter was read from Professor Cope to the Secretary, dated Fort Wallace, Kansas, 10th month 9, 1871, giving a preliminary report of his expedition into the Valley of the

Smoky Hill river, Kansas, and descriptions of new fossil sauroids and Chelonians discovered and collected there.

Pending nominations No. 679 and new nominations, Nos. 680 and 681 were read, and the meeting was adjourned.

FORT WALLACE, KANSAS,
October 9th, 1871.

My Dear Prof. Lesley :—

I write to give a brief account of the expedition of seventeen days, which I have just made in the valley of the Smoky Hill river in Kansas. Through the courtesy of Gen. Jno. Pope, commanding the Department of the Missouri, I was furnished with an order on the post commandant at Fort Wallace for a suitable escort. This was furnished by Capt. E. Butler (5th infantry), who spared no pains to make the expedition a success.

We first camped at a spring eighteen miles south of Fort Wallace, and five miles south of Butte Creek. It had a fine flow of water, and being without name I called it Fossil Spring. On a bluff, on Butte Creek, Lieut. Whitten discovered the fragments of a monster saurian projecting from the shale, and on following the bones into the hill, exhumed a large part of the skeleton of *Liodon dyspelor* Cope (Proceeds. A. P. S. for 1870). This was welcome, as the species had been previously known from vertebræ only. The pelvic arch was found perfectly preserved, and the scapular arch and limbs partially so. The iliac bone is slender and straight, slightly expanded at the acetabulum. The ischium has a somewhat similar form, but is curved. The axis of the proximal portion is directed upwards; the shaft then turns into a horizontal direction, and lies beneath and at one side of the vertebral column without uniting with its fellow. The pubes are elongate, but wider than the other elements and flattened. They are in contact in front medially, and have an angulate axis. A short process projects from near the proximal end, on the exterior margin. The femur is a flat bone, slightly constricted medially, and with a decurved and projecting portion of the proximal articular, surface on the inner side representing a head. The extremities of the dentary bones are each drawn to an acute point differing thus *toto coelo* from those of the *L. proriger*.

On the same bluff another *Liodon* and a *Clidastes* were found, with five species of fishes.

On examining neighboring bluffs and denuded areas, bones supposed to be those of *Pterodactyle*, two species of *Clidastes*, a *Dinosaur*, a *Crocodile*, and numerous fishes were brought to light.

In a similar location on Fox Creek canon, one of the escort, Martin V. Hartwell, to whom I am indebted for many fine discoveries, observed the almost entire skeleton of a large fish, furnished with an uncommonly

powerful offensive dentition. The jaws were stout, the dentary bone very deep. The teeth in a single row in all the bones, but of irregular sizes. There are two or three very large canines in each maxillary, and one in the premaxillary, three or four in the dentary separated by an interval. The lack of coronoid bone and many other characters show that it should be referred to the order *Isospondali*, and is probably allied to the herring and the *Saurodontidae*. The vertebræ are grooved, and there is a basi-occipital tube but little developed. The teeth are simple cylindric conic, with smooth enamel, and project two inches above the alveolar border, and each descends an inch into its alveolus. The species and genus are new to our palaeontology, and may be named *Portheus molossus*. It turned out on subsequent exploration to have been quite abundant in the Cretaceous seas. It was probably the dread of its cotemporaries among the fishes as well as the smaller saurians.

On another occasion, we detected unusually attenuated bones projecting from the side of a low bluff of yellow chalk, and some pains were taken to uncover them. They were found to belong to a singular reptile, of affinities probably to the Testudinata, this point remaining uncertain. Instead of being expanded into a carapace, the ribs are slender and flat. The tubercular portion is expanded into a transverse shield to beyond the capitular articulation, which thus projects as it were in the midst of a flat plate. These plates have radiating lines of growth to the circumference, which is dentate. Above each rib was a large flat ossification of much tenuity, and digitate on the margins, which appears to represent the dermo-ossification of the Tortoises. Two of these bones were recovered, each two feet across. The femur resembles in some measure that ascribed by Leidy to *Platecarpus tympaniticus*, while the phalanges are of great size. Those of one series measured eight inches and a half in length, and are very stout, indicating a length of limb of seven feet at least. The whole expanse would thus be twenty feet if estimated on a Chelonian basis. The proper reference of this species cannot now be made, but both it and the genuss are clearly new to science, and its affinities not very near to those known. Not the least of its peculiarities is the great tenuity of all the bones. It may be called *Protostega gigas*.

The greater part of a large *Liodon proriger* Cope was found scattered over a denuded surface at one point, his huge truncate, bowsprit-like snout, betraying his individuality at once. Portions of other examples of this reptile were afterwards found. Remains of several species of *Clidastes* occurred at various points in the neighborhood of Fossil Spring. One was found in the side of a bluff fifty feet above the bottom of the cañon; Martin Hartwell exhumed another near the *C. cineriarum* Cope almost complete.

We subsequently left this locality and encamped at Russell Springs on the Smoky Hill, twenty-six miles distant. On the way a large *Clidastes* of some forty or more feet in length was found lying on a knoll of shale, with the head displaying the palatal surface upwards. On the Smoky

our explorations were attended with success. When we shifted camp, it was to go to Eagle Tail in Colorado, whence we returned again to Fossil Spring. The richness of this locality was again apparent, and we added to our collection a number of species. Among these may be mentioned *Liodon ictericus* Cope and two new *Clidastes*. The writer originally pointed out the existence of representatives of the orders *Pythonomorpha* and *Sauropterygra*, in this cretaceous basin. Prof. Marsh's explorations determined the existence of *Ornithosauria* and *Crocodilia*. The present investigation adds *Dinosauria* and perhaps *Testudinata*, or the group that the new form *Protostega* Cope represents.

The preceding account expresses some of the points of interest observed. These, with others, now unnoticed, will be included in a final report.

The giants of this sea were the *Liodon proriger*, Cope, L. *dyspelor*, Cope, *Polycotylus latipinnis*, Cope, and *Elasmosaurus platyurus*, Cope. Of these the first was apparently the most abundant. The second was the most elongate, exceeding in length perhaps any other known reptile. The last named had the most massive body, and exhibited an extraordinary appearance in consequence of the great length of its neck.

For kind assistance, I am much indebted to Capt. Edwin Butler, post commandant at Fort Wallace, to Dr. W. H. King, post surgeon, and to Capt. Wyllys Lyman. To Lieut. Jas. H. Whitten and Sergeant W. Gardner, who accompanied the expedition, much of its success is also due.

I am, etc., EDW. D. COPE.

Stated Meeting, Nov. 3d, 1871.

Present, eleven members.

Vice President, CRESSON, in the chair.

Letters of envoi were received from the societies at Riga Chemnitz, Wiesbaden, Lyons and Copenhagen, the University of Norway, and the Royal Geographical Society at London.

Letters of acknowledgment were received from the Nassau N. History Union at Wiesbaden, (Proceedings 78–83,) and the Imperial Society of Agriculture and Natural History at Lyons, July 20, (73–81,) requesting the completion of their series, which, on motion, was so ordered.

Donations for the Library were received from the Societies at Riga, Chemnitz, Görlitz, Wiesbaden, Lausanne, Lyons, Liverpool, Glasgow and Salem, Mass., the Berlin Academy, Geological Society, and Archæological Institute, the Austrian Geological Institute, Anthropological Society, Herr von Hauer,

Mr. Neumeyr and Dr. Emanuel Bunzel, the Danish Antiquarian Society, the Norwegian University, the Revue Politique, M.M. Delesse and Lapparent, the British Association, Meteorological Office, Meteorological, Geographical, Chemical, Geological, Zoological and Antiquarian Societies of London, the Editors of Nature, the American Journal of Science and Art, the Protestant Episcopal Diocesan of Pennsylvania, and the Chief of Engineers of the U. S. Army.

The death of Sir R. I. Murchison, in the eightieth year of his age, at London, on the 23d instant, was announced by the Secretary.

The loss by shipwreck, in a recent storm, on Lake Superior, of James T. Hodge, a member of the society, was announced by Secretary, with appropriate remarks.

Prof Cope made some general observations on the extinct Batrachian Fauna of the Carboniferous of Linton, Ohio., based on studies of material obtained by Prof. J. S. Newberry, Director of the Geological Survey of Ohio.

Twenty-seven species had been discovered up to the present time, and not one of them was a reptile; twenty-three of these were referred to the following genera: *Pelion*, Wyman, 1; *Sauropleura*, Cope, 3; *Tuditanus*, Cope, 4; *Brachydectes*, Cope, 1; *Oëstocephalus*, Cope, 6; *Cocytinus*, Cope, 1; *Molgophis*, Cope, 1; *Phlegethontia*, Cope, 2; *Colosteus*, Cope, 3; *Eurythorax*, Cope, 1.

Tuditanus, *Cocytinus* and *Phlegethontia* were described as new genera. The first represented *Dendrerpeton*, but possessed the usual three thoracic shields, a character not yet found in the former genus.

Phlegethontia embraced slender snake-like forms allied to *Molgophis*, but without ribs. *Cocytinus* was a branchiferous genus having four branchihyal bones, two basals branchihyals and two ceratohyals on each side, and with conic teeth in the anterior portion of the mandible only, on an expansion or dental plate. Limbs none in front.

Oëstocephalus was defined as having the three pectoral shields, posterior limbs only present and weak; head lanceolate; ventral armature of packed osseous rods *en chevron*; neural and haemal spines of caudal vertebrae expanded and fan-like. The six species were enumerated, viz: *O. remex*, Cope, *O. pectinatus*, C., *O. marshii*, C., *O. curvidens*, C., *O. vinchellianus*, C., *O. serrula*, C., the last three being new to science. Other new species were described, as *Sauropleura longipes*, C., and *S. brevipes*, C., *Tuditanus brevirostris*, C., *T. mordax*, C., and *T. radiatus*, C., *Cocytinus gyrinoides*, C., *Phlegethontia linearis*, C., was indicated as a species with lanceolated head, no ribs, a very elongate tail, and without limbs or ventral or thoracic armature. *Phlegethontia serpens*, C., was a larger species. A new *Colosteus*, *C. pauciradiatus* was added, and an allied form described as *Eurythorax sablaevis*. The pectoral median shield is subround and nearly smooth, and belonged to an animal of four feet in length.

Sauropleura, *Cocytinus*, *Molgophis*, *Phlegethontia* were enumerated as genera in which pectoral shields had not been observed, and *Pelion* and *Tuditanus* were characterized as the broad-headed types.

Cyclical Rainfalls at *Lisbon*.

By Pliny Earle Chase.

Read before the American Philosophical Society, Aug. 18, 1871.

The more strongly marked and decisive character of the curves of lunar monthly rainfall, in Philadelphia than in Great Britain, (*ante* v. x., pp. 523–34,) rendered me desirous of obtaining observations from some European station in lower latitude. The intimation of that desire to the Director of the "Observatorio do Infante Dom Luiz," at Lisbon, was promptly followed by the transmission of a copy of observations extending over a period of sixteen years, which is herewith presented. I also submit some of the tabulated results of such discussion of the observations as I have already undertaken, which appear to me to corroborate, in a most satisfactory manner, the views I have hitherto advanced respecting the meteorological influence of the moon. Some of the tables also afford interesting indications of a somewhat similar planetary influence, sufficient, as it seems to me, to encourage further investigation.

One of the objections most often urged against the acknowledgment of

TABLE I.

Different and non-correspondent Rainfalls at Lisbon, in Lunar and Solar periods, from December 1, 1854, *to December* 1, 1870. *R.=Total fall; N.=Normal percentage of rain.*

DAY OR YR. + 30.	LUNAR MONTHLY.							SOLAR YEARLY.						
	Dec.	Mar.	Apl.	July.	Aug.	Nov.	Yr.	1855+3N*		1856+3N*		1857+3N*		Av.
☽ ⊙	R.	N.	R.	N.	R.	N.	N.	R.	N.	R.	N.	R.	N.	N.
1	298.0	123	45.9	82	154.5	95	106	184.7	102	275.7	192	238.9	160	1·6
2	223.9	115	79.7	80	143.1	104	106	120.7	121	329.7	186	112.6	143	148
3	174.8	97	53.5	94	156.5	103	99	216.8	158	139.9	161	121.8	131	152
4	136.9	85	63.6	97	124.4	93	90	451.3	192	176.4	138	161.4	130	158
5	153.5	83	75.9	98	104.9	81	85	342.9	194	193.6	127	109.0	135	156
6	189.8	81	68.3	96	66.3	78	83	257.4	164	94.0	123	192.9	133	142
7	141 8	78	42.9	94	113.5	89	84	224.0	121	242.6	119	131.1	116	119
8	106 7	78	88 8	93	181.1	102	89	69.5	87	102.2	112	92.2	94	97
9	187.2	85	37.4	96	118.0	104	93	106.0	75	118.5	109	16.7	91	90
10	182.9	95	83.1	102	168.9	98	98	130.6	70	164.3	110	147.6	114	95
11	185.3	108	67.7	109	74.0	98	105	112.5	69	200.7	99	191.8	132	95
12	252.0	121	83.3	116	111.7	114	118	118.9	59	33.8	75	168.8	118	80
13	269.8	128	71.6	121	267.0	132	128	78.8	42	84.0	49	33.7	81	55
14	271.7	124	113.0	118	187.0	133	126	11.2	23	36.8	31	64.9	49	32
15	173.1	118	46.2	107	118.7	122	118	6.8	11	5.3	17	12.3	25	17
16	214.7	119	73.2	101	146.9	122	117	15 8	7	16.4	9	5.2	12	9
17	272.6	128	53.5	107	195.1	134	126	7.9	6	1.8	7	5.9	7	7
18	260.8	135	89.5	123	204.1	141	135	6.5	7	0.0	8	0.0	12	9
19	266.0	136	102.9	138	207.5	132	135	12.9	12	33.2	11	11 1	26	16
20	289 8	124	97.3	145	135.5	114	124	27.6	23	2.1	22	86.1	39	27
21	199.1	101	105.7	135	98.9	98	106	52.1	45	20.8	50	35.3	46	47
22	99.3	75	91.7	108	163.9	87	85	93.5	83	118.6	97	35.7	54	80
23	105.1	60	30.1	74	69.5	77	68	231.2	129	261.2	135	63.5	72	116
24	97.2	57	12.0	58	84.0	72	62	342.7	166	223.1	150	148.0	92	141
25	123.2	64	42.4	64	120.7	72	67	304.1	192	157.6	142	74.8	109	153
26	112.3	76	67.5	82	65.4	77	77	208.5	212	152.3	134	140.4	135	166
27	244.7	87	61.6	94	134.4	82	86	625.4	216	226.5	131	143.2	174	177
28	118 7	95	79.6	94	124.2	83	91	275.6	182	101.5	134	341.4	200	171
29	219.1	105	52.0	86	102.7	81	93	85.9	131	214.0	150	177.8	195	154
30	214.7	118	44.5	79	71.4	84	100	177.3	104	218.6	174	143.5	177	146

* 1855, '58, '61, '64, '67, '70; 1856, '59, '62, '65, '68; 1857, '60, '63, '66, '69

any appreciable lunar or planetary influence upon rainfall or other atmospheric phenomena, is based on the different, and sometimes contradictory, results obtained by different investigators, from observations in different places and at different times; another arises from the difficulty of conceiving any tidal or other force adequate for the production of any considerable disturbance. Nevertheless, such of the objectors as are familiar with Howard's discussion of the moon's influence upon the barometer; Sabine's, of lunar disturbances of terrestrial magnetism; or Schwabe's and Wolf's, of the dependence of sun-spots upon planetary configurations, seem to admit—at least I am not aware that any of them deny—the probability of the conclusions which those eminent observers have severally expressed.

If it is conceivable that Saturn, Jupiter and Venus can in any way affect the cloudiness, or amount of spotted surface of the the sun, notwithstanding the immense preponderance of his attractive, magnetic and other supposable forces, it is surely much more easy to imagine that they may similarly affect the meteorologic phenomena of the earth, which opposes an antagonizing mass only $\frac{1}{326800}$ (according to Newcomb's estimate) as great as that of the sun. If the lunar tides of our atmosphere are of sufficient magnitude to affect the barometer, the consequent waves must effect a blending of aerial currents of different temperatures and

TABLE II.

Correspondent Rainfalls at Lisbon, in Lunar and Solar periods.

DAY OR YR. + 30.	LUNAR MONTHLY.							SOLAR YEARLY.						
	1855-60.		1861-65.		1866-70.		Av.	1855-60.		1861-65.		1866-70.		Av.
☽ ⊙	R.	N.	R.	N.	R.	N.	N.	R.	N.	R.	N.	R.	N.	N.
1	115 0	87	170.1	97	178.7	141	104	222.4	131	298.2	150	178.7	171	146
2	146.8	85	154.2	95	151.9	144	103	235.6	148	208.5	144	118.9	155	148
3	116.2	84	134 3	90	150 4	133	98	231.0	162	78.6	145	168.9	146	152
4	108.4	85	147.0	83	96.6	117	91	369.9	162	290.0	162	129.2	148	158
5	158.7	87	106.3	76	119.0	101	86	218.5	142	283.5	175	143.5	154	156
6	124.7	87	108 0	73	84 7	86	81	103.1	119	236.7	163	204.5	150	142
7	102.9	90	102 8	77	69 6	73	81	223.8	1 8	226 9	128	147 0	126	119
8	158.2	99	172.8	83	53.4	66	85	162 3	105	51 6	89	50.0	96	97
9	173.5	112	93.3	87	76 0	66	91	126.6	101	73.9	71	40.7	95	90
10	162.4	126	180.3	93	73.3	69	94	209.6	97	98.6	76	134.3	118	95
11	231.9	139	120.1	103	50.9	79	110	124 2	88	140.9	85	239 9	124	95
12	235.5	145	193.6	117	98.1	99	123	111.8	74	163.5	79	46.2	91	80
13	205.2	140	264 1	124	164.5	118	128	112.5	59	52.6	56	31.4	47	55
14	216.2	128	153.6	118	102.9	125	123	75 8	40	31.4	31	5.7	21	32
15	118.1	119	152.3	109	154 8	121	116	3.9	22	11.8	15	8.7	12	17
16	194.4	121	193 6	105	91.3	116	114	15.8	10	7.7	7	13 9	10	9
17	199.1	130	136.6	108	117.6	118	118	.8	5	6.2	5	8.6	12	7
18	202.7	133	165.9	119	114.7	128	127	.3	7	.1	7	6.1	15	9
19	239.2	123	246.6	135	176.8	137	131	21 2	14	1.5	15	34 5	20	16
20	120.4	102	234.4	141	144.6	127	123	38.2	24	68.6	26	9 0	31	27
21	104.9	81	251.9	128	113.0	99	104	49.4	40	22 0	47	36.8	51	47
22	117.3	65	135.3	105	40.3	69	82	76.9	79	60 8	86	110.1	72	80
23	60.8	55	92.5	91	29.4	55	69	218.4	124	261.7	136	75.8	79	116
24	58 6	56	158 0	90	70.8	56	70	350.6	159	254 0	171	109 2	73	141
25	87.8	70	182.3	93	78.8	59	77	215.7	179	312.1	176	8.7	79	153
26	175.8	86	112.8	91	28.3	65	84	298.5	194	156.8	165	45.9	124	166
27	149.2	93	143.4	90	72 4	81	89	458.0	191	238.4	156	298.7	185	177
28	96 8	93	148.9	91	133.2	103	95	223 6	163	233.9	149	261.0	211	171
29	180.4	92	145.5	93	129 8	118	99	134.8	130	177.9	143	165.0	200	154
30	121.2	90	141.2	95	97 9	130	102	179.3	121	141.4	145	218.7	185	146

different degrees of humidity; and in consequence of the stratification of the upper and lower winds, this blending offers a unique opportunity for the practical study of the opposite tidal tendencies in deep and shallow fluid seas or envelopes. If the lunar are as unmistakable as the solar modifications of magnetic phenomena, the analogies which have been pointed out, by Messrs. Baxendell and Bloxam between magnetic and pluvial and by myself between pluvial and auroral curves, are indicative of other possible lunar influences which are equally unmistakable. If the difficulty of conceiving an adequate cause for a supposed phenomenon were to deter us from inquiring whether an apparent dependence were real or illusory, all progress in science would become impossible. Finally, if it can be shown that solar rain-curves exhibit different, and often contradictory inflections, similar to those which are objected to in the lunar curves, and if a consistency of disagreement can be shown between the lunar results at two given stations, accompanied by a consistency of agreement between the results in different cycles at the same station, the argument from apparent contradiction will be deprived of all its force.

I have no hope of thoroughly convincing any one who is skeptical of lunar influence on the weather by deductions from observations at one or two, or a half dozen stations, but I believe that any one who will examine, carefully and impartially, the tables I have already published, based on observations in India, Great Britain, Portugal, Canada and different portions of the United States, will at least be willing to admit

TABLE III.

Lisbon Rainfall in Synodic years of Jupiter.

Syn. Yr. + 30.	1853-60.	1861-65.	1866-71.	Dec. Mar.	Apl. July.	Aug. Nov.	Year.
1	141	177	45	139	70	110	117
2	127	148	41	121	74	93	103
3	111	101	49	87	78	90	86
4	98	65	70	62	79	94	76
5	89	48	99	61	78	97	76
6	81	43	128	70	80	96	81
7	79	43	146	78	89	102	88
8	88	45	151	84	96	112	96
9	110	45	150	95	97	117	103
10	139	45	143	106	103	112	108
11	156	44	141	105	121	121	113
12	146	39	154	90	137	143	116
13	119	36	165	77	133	151	112
14	99	37	146	74	115	124	98
15	99	37	112	83	94	81	84
16	108	36	100	100	89	51	81
17	109	45	114	113	104	46	88
18	96	68	132	117	125	60	99
19	80	98	138	121	131	79	108
20	67	123	127	126	115	84	110
21	53	131	101	117	91	79	99
22	45	129	73	95	78	76	86
23	58	134	58	79	87	91	84
24	72	153	58	79	111	112	96
25	84	168	60	95	127	114	107
26	83	196	60	117	123	99	112
27	86	200	61	128	110	93	113
28	106	191	64	125	100	110	115
29	132	183	61	124	90	130	120
30	145	183	53	133	76	130	122

that the question is an open one. And if he will compare my previous tabulations with those which accompany the present paper, he may, perhaps, find any lingering skepticism shaken, however prejudiced or inveterate it may be.

For convenience of comparison, I represent, in each instance, the mean rainfall for the entire period under consideration by 100, and any deviation from the mean, whether of excess or deficiency, is denoted by the addition or subtraction of a corresponding percentage. The smoothing by successive means is uniform in all the tables. I invite special attention to the columns of lunar rainfall at Lisbon, in each of the first two tables, representing two different sets of three independent periods, averaging 64 months, a cycle which I have hitherto supposed too short to yield any satisfactory results. If there is no causal nexus, it is difficult to imagine any possible reason for the striking similarity between the ordinates for the different cycles, a similarity which I think quite as striking as that between the solar curves at the same station for independent periods of similar duration. If the lunar disturbances are considered as merely tidal, while the solar are partly tidal, but principally thermal, their relative magnitudes suggest interesting comparisons between centrifugal and centripetal forces, analogous to those which I have hitherto had the honor of presenting to the Society.

The resemblance between the independent curves in Table III. is not very marked ; but the yearly mean is curiously like the yearly averages of the lunar monthly ordinates in Tables I. and II., if we construct the curves so as to compare the ordinate of Jupiter's opposition, No. 16, with the ordinate of lunar conjunction, No. 1, and *vice versâ*.

TABLE IV.

Comparative Daily and Yearly Rainfalls.

☉ H. ☽ Yr.	PHILADELPHIA.						GREENWICH.			
	June.	Dec.	April.	Oct.	Averge Daily.	Ave'ge Annu'l.	Jan.	July.	April.	Oct.
1.....	123	92	120	114	91	92	53	92	120	90
2.....	111	78	130	112	91	89	54	103	143	126
3.....	92	72	127	103	93	89	63	107	169	148
4.....	77	71	118	97	98	90	66	112	179	146
5.....	69	71	103	106	105	91	64	118	155	122
6.....	71	73	86	105	110	94	65	129	110	98
7.....	79	81	77	105	113	99	72	139	74	82
8.....	84	95	78	110	113	105	74	140	60	75
9.....	80	102	78	125	112	110	72	136	59	79
10.....	68	96	70	140	109	113	78	133	63	85
11.....	56	87	64	143	105	112	99	128	65	82
12.....	55	85	67	135	102	110	127	109	66	72
13.....	66	90	74	117	103	109	141	89	72	65
14.....	92	100	82	93	106	111	131	94	86	66
15.....	131	116	94	71	109	112	111	126	101	76
16.....	172	136	111	58	108	108	97	148	115	97
17.....	186	144	124	55	104	101	98	129	125	121
18.....	162	133	124	56	98	95	116	88	124	133
19.....	123	113	122	65	92	91	145	56	111	129
20.	98	102	125	79	87	95	170	40	90	121
21.....	90	106	123	97	85	96	173	30	73	112
22.....	92	119	106	106	87	96	150	32	66	98
23.....	102	124	93	107	90	96	110	49	76	85
24.....	118	112	101	109	91	95	72	73	98	84

The tendency to opposition between rainfall curves on opposite sides of the Atlantic, of which I have already submitted some illustrations to the Society (*ante*, p. 38, &c.), is interestingly shown near the solstitial and equinoctial periods, by Table IV.* Columns 6 and 7 of the same table indicate a similarity between the curves of daily and annual rainfall at Philadelphia, which lends additional interest to my comparison of pluvial and auroral curves (*ante*, pp. 121–22).

Explanation of Figures.

The horizontal lines represent the average rainfall; each vertical space represents a deviation of .2 of the mean value; each horizontal space represents two days in the abscissas of the lunar curves, or $\frac{1}{15}$ of a year in the abscissas of the solar curves. The lunar curves begin and end with the day of new moon; the solar curves with January 1.

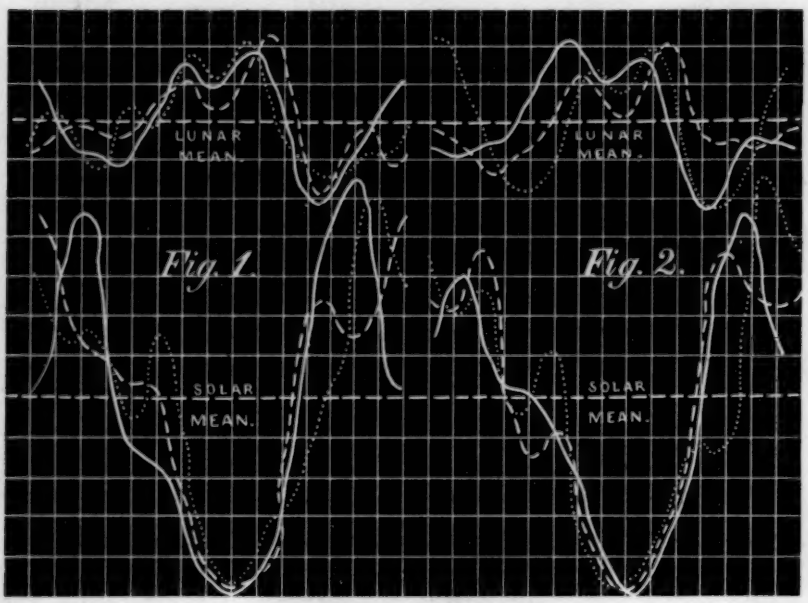

Fig. 1.—*Lunar Curves.*

December to March, inclusive; continuous line.
April to July, inclusive; broken line.
August to November, inclusive; dotted line.

Solar Curves.

1855, '58, '61, '64, '67, '70; continuous line.
1856, '59, '62, '65, '68; broken line.
1857, '60, '63, '66, '69; dotted line.

Fig. 2.

1855–'60; continuous line.
1861–'65; broken line.
1866–'70; dotted line.

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LISBON RAINFALL.

Dec. 1, 1854. to Dec. 1, 1855.

Day.	Dec.	Jan.	Feb.	Mar.	Ap.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Total
1			4.3			4.3	0.8				16.5	0.3	26.2
2			26.7		0.5	1.1					1.5		29.8
3	1.9		2.2	0.5		14.3				2.2	0.4		21.5
4	4.9		8.1	19.5		3 2				13.2	8.9		57,8
5			8.6	2.7		2.3				1.3			14.9
6	0.5		5.7			0.3					7.6		14.1
7			0.5	4.0			0.3			0.6	16.2		21.6
8			3.5	3.3						8.6	6.5		21.9
9			7.6	1.3						2.4	52.8	4.4	68.5
10			8.9					13.2		0.5	2.2	1.5	26.3
11			2.4								0.3	0.1	2 8
12			27.0										27.0
13		0.5	23 8		0.2						13 0		37.5
14		0.3	3.5		2.2						13 5		19.5
15			8.6		0.3	0.3					2.7	0.7	12.6
16		0.6	24.6		16 2	1.1							42.5
17		0.8	2.5		8.1						17.0		28.4
18		3.0	19.2		0.3						6 3	2.3	31.1
19		2.4	7.3		4.3					0.3	0.3	10.7	25.3
20			6.0	3.5									9.5
21				6.2	11.1							16.4	33 7
22		0.5	14.3	4.6	3.8					20.0	11.9	10.9	66.0
23			0.8	6.5	0.5					0.8	9.2	13.0	30.8
24				15.9							0.6	1.0	17.5
25			0.5	2 7	8.1	5.6							16.9
26		17.3		18.9		31.3				8.4			75.9
27		19.7		27.2		3.0			0.8	0.5	5.0		56.2
28		1.1	0.5			7.3				4.0	4.0		16.9
29		9.7		9.2		14.6				30.5		6.6	70.6
30				0.5		0.8		0.3		0.8	0.8	2.0	5.2
31						1.1					1.3		2.4
Sum	7.3	55 9	217.1	126.5	55.6	90.6	1.1	13.5	0.8	94.1	198.5	69.9	930·9

Dec. 1, 1855, to Dec. 1, 1856.

Day.	Dec.	Jan.	Feb.	Mar.	Ap.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Total
1		8.5	16.8		6 2	6.1							37 6
2		7.3	3.3		3.2						0.8		14 6
3		30.6	6.9		0.8						0.6		38.9
4		3.6			9.9					1·3	0.4		15.2
5		28.3			3.8					0·1	50.9		83.1
6		9.4			0.3					0·1	4.1		13.9
7	3.6	12.9		7.7									24 2
8		12.9		3.8	11.8						1.1		29.6
9		12.9		0·2	2 4							1.5	17.0
10	1.0	11.4		1.1	0.9								14.4
11	1.6	6.2		2.6									10.4
12				6.0	6.7							1.9	14.6
13		0.8	10.8	1.5	7.6						3.5		24.2
14		0.3	5.1	11.7	0.7								17.8
15		6.2	6.8	5.4	6.2								24.6
16	0.7	11.3	1.7	43 4									57.1
17	6.7	0.8	7.0	26.5	0.3				1.0				42.3
18	4.9	40.9	3.4	12.1					6.2			0.7	68.2
19	0.8	18.7	16.8		0.7								37 0
20	27.5	8.4	1.8		0.3				1.3				39.3
21	3.4	11.7	1.1			1.1							17.3
22		0.5											0.5
23	0.3	1.6	18.3	0.3		2.3							22.8
24	0.8	6.3		4.1	16.5	1.5				4.3			33.5
25	3.7	24.8			6.0	0.3							34.8
26	5.8	7.9		18.9	35.9								68.5
27	46.8	3.9		5.5	6.8					9.2			72.2
28	1.9	3.5		0.6	1.3	1.2				0.1			8.6
29				0.5	3.6	4.4				4.3		0.1	12.9
30													
31	12.5										5.3		17·8
Sum	122.0	291.6	99.8	151.9	131.9	16.9	0.0	0.0	8.5	19.4	66·7	4.2	912.9

LISBON RAINFALL.

Dec. 1, 1856, to Dec. 1, 1857

Day.	Dec.	Jan.	Feb.	Mar.	Ap.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Total
1				2.4	7.9		3.6				3.2	17.7	34.8
2	5.0		8.3	0.6		0.3		0.2			0.9	6.5	21.8
3	8.5	1.3	5.0		0.7	1.0						27.6	44.1
4	0.1	1.3	0.2		1.3							5.2	8.1
5	10.5	0.4			0.3							10.6	21.8
6	3.0	7.6				0.5							11.1
7			0.1	1.1		1.1					7.6		9.9
8	0.7		6.6	1.1		0.7				0.2			9.3
9	20.7		39.5		3.5	1.3				1.0			66.0
10	6.7		30.0		1.1	14.9				1.0		1.8	55 5
11	0.9	1.4	12.2	1.3									15.8
12	2.0	6.5	0.2										8 7
13	11.3	4.8	0.5	3.2		0.7							20.5
14	0.5		3 5	0.1	0.1	0.7							4.9
15			1.2		0.2		0.6					4.3	6.3
16			6.2				10.0					28.9	45.1
17			1.9	4.3			15.6					11.5	33.3
18				7.4			4.8				12.0		24.2
19			5.1								17.5		22.6
20		0.3	1.7	17.3						5.9			25.2
21	5.0	9.2		0.2		1.7				2.0			18.1
22	1.5					1.9			0.7	1.0			5.1
23		0.5	0.2			10.4			25.9			28.0	65.0
24		8.1	0.7	11.1		26.0				0.3	4.3	0.6	51.1
25	0.5	6.5		0.2		1.5				3.2	19.9	12.0	43.8
26	8.9	1.2			0.2	2.4					11.0	1.0	24.7
27	0.9	0.5				2.1					0.9		4.4
28	2.6			1.1					0.3			21.5	25.5
29									6.2		1.4	35.4	43.0
30				12.2	0.7					3.1		11.4	27.4
31		5.8		5.4							4.0		15.2
Sum	89.3	55.4	123.1	69.0	16.0	67.2	34.6	0.2	33.1	17.7	82.7	224.0	812.3

Dec. 1, 1857, to Dec. 1, 1858.

Day.	Dec.	Jan.	Feb.	Mar.	Ap.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Total
1				30.5	0.3	0.2		0.1					31.1
2				15.0	0.2	0.7							15.9
3	21.1			6.8		0.2							28.1
4	0.4	8.8	2.5	7.5		5.0						17.3	41.5
5			7.5		0.6							0.8	8.9
6			0.6										0.6
7		4.8	5.7		4.8								15.3
8			0.3		3.3							1.2	4 8
9			8.1		1.4	5.0						40.5	55 0
10			8.5			6.0					12.6	37.2	64.3
11			10.0			2 9					0.1	0.4	13.4
12			18.3	1.8	2.5	0.2						20.4	43.2
13			0.8									7.8	8.6
14												4.7	4.7
15						2.0						55.9	57.9
16										0.6		0.6	1.3
17			12.0								21.5	6.7	40.2
18			17.6				0.2		2.6		7.5	60.9	88.8
19	13.8										30 5	0.8	45.1
20			4.0							29.3	2.3	10.2	45.8
21			20.8	0.2						8.2		3.7	32.9
22			14.7								1.9	22.0	38.6
23			1.9	8.4							17.1	22.8	50.2
24			67.						1.1		7.9	26.9	42.6
25			0.6						0.2			27.9	28.7
26		9.6	6.2									14.6	30.4
27		8.7	4.0							6.6		6.3	25.6
28			6.2							7.0		2.0	15.2
29							2.9					9.7	12.6
30				2.0								13.2	15.2
31				5.7									5.7
Sum	35.3	31.9	157.0	77.9	13.1	22.2	3.1	0.1	3.9	51.7	101.4	414.5	912.1

LISBON RAINFALL.

Dec. 1, 1858, to Dec. 1, 1859.

Day.	Dec.	Jan.	Feb.	Mar.	Ap.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Total
1			0.5			2.2	9.0						11.7
2	0.3		0.2			0 3	8.3						9.1
3	0.5					3.8	1.3					9.8	15.4
4						23.3	1.2				1.5	20.3	46.3
5			2.9			1.0	4.4				0.6		8.9
6			2.0			0.6	12.2				9.6		24 4
7			6.0				13.8				0.8		20.6
8			0.5				3.4				19 3		23.2
9							3.9				4.2		8.1
10			13.6		0.3						0 8		14.7
11			0.5		0.2						20.0		20.7
12			0.2			19.1	7.9				40.7		67.9
13	9.8					10.7	0.8				13.0	1.5	35.8
14				0.5			1 4				6.2		8.1
15							2.9			0.4	12 2		15.5
16	25.4												25.4
17	2.0					0.1				0.4	9.3		11.8
18	13.7				28.1				0.3		0.5		42.6
19	1.9				19.3			0.8					22.0
20	1.2				5.3	6.6						20.7	33.8
21		1.8			4 2						5.1	9.5	20.6
22		17 3			3.3	2.7					11.0	4 2	38.5
23	15.0	0.3			0.1						1.6	0.5	17.5
24	3.1				1.0							8.7	12.8
25											23.0		23.0
26		0.2			0.3							0.1	0.6
27					18.0						17.0	0.8	35.8
28	0.2	0.1			0.4	1.7				1.0	31.7		35.1
29				4.1	19.9	3.4							27.4
30		5.5		1.0	4.2	12.4					0 6		23.7
31		3.3				3.7					0.3		7.3
Sum	73.1	28.5	26.4	5.6	104.6	91.6	70.5	0 8	0.3	1.8	229.0	76.1	708 3

Dec. 1, 1859, to Dec. 1, 1860.

Day.	Dec.	Jan.	Feb.	Mar.	Ap.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Total
1	0.4	2 5	0.1		14.3					2.7		2 1	22.1
2		12 6					1.3			6 3		1.7	21.9
3	14.4	7.7			12.1								34.2
4		2.4			7 7							0.6	10.7
5		6.3			1.8								8.1
6	5.1	3.2			0.4							12.5	21.2
7				4.4								3.6	8 0
8	11.2	0.5	3.9									1.5	17.1
9		0.4	2.9				4.7	2.5		6.3		2.4	19.2
10		1.9										23.5	25.4
11				2.4						1.6		9.8	13 8
12		1.6	0.3	2.0		2.1	1.5					1.0	8.5
13		37.1		1.3			3.5					14.8	56.7
14		0.3				2.7						0.2	3.2
15				0.1			5 2		10.1			7.2	22.6
16		4.7										14 8	19 5
17		4.6			2.1	0.7						4.9	12.3
18		12.6			1.0	12.2				0.8		1.5	28.1
19		0.4					7.0					1.2	8.6
20		6.1					3.8					3.1	13 0
21		0.2											0.2
22		3.7	2.4									1.0	7.1
23	0.5	0.9										1.2	2.6
24	0.3	2.0	4.5							0.5		1.2	8.5
25	22.6	0.6	12.7		30.9							5.7	72.6
26		0.2			15.5							4.9	20.6
27	3.7	2.3	0.5							12.0		6.4	24.9
28	4.6			5.1						1.2	3.8	9.4	24.1
29	3.2										7.7	5.4	16.3
30	0.1	0.6										2.8	3.5
31		2.1		3.6									5.7
Sum	66.1	117.5	27.3	18.9	85.8	17.7	27.0	2.5	10.1	31.4	11.5	144.4	560.2

LISBON RAINFALL.

Dec. 1, 1860, to Dec. 1, 1861.

Day.	Dec.	Jan.	Feb.	Mar.	Ap.	May.	June.	July	Aug.	Sept.	Oct.	Nov.	Total
1	17.4										1.6	0.3	19 3
2	23.4					1.0					12.6		37.0
3	12.1	6.2									9.2		27.5
4	4.4	0.4											4.8
5	4 3	15.4						0.5					20.2
6	15.8	1.0	3.2								4.8		24.8
7	28.5		15 4								1.6		45.5
8	17.5		3.0			7.2						16.4	44.1
9	1.2		43.3										44.5
10	2.6		19.7				2.7				25.7	14.0	64.7
11	1.2		0.2							2.9		2.8	7.9
12			4 8								0.8	5.9	10.7
13	2.6		2.1									6.1	10.8
14	0.3	6.1	31.5				0.2	2.6			5.2		45.9
15		20.5	5.6		5.7						36.3		68.1
16		2.0	1.1			16.3	1.2				10.8	7.2	38.6
17			18.5			7.3	4.2					15.8	45.8
18	1.3		29.9			6.4						4.8	42.4
19	0.8		3 3		1.3						3.8	1.4	10.6
20			7.1		9.4	2.6						31.6	50.7
21	6.0		2.6		4.0						1.3	6.6	20.5
22	10 4		28.7		1.6						0.1		40.8
23	6.4		3.7			2.8	2.8						15.7
24	30.3		0.2		4.0					2.4		0.4	37 3
25	14.6									3.7		4.4	22.7
26	0.3		2.9		0.6	6.0		0.4			14.0	1.2	25 4
27	7.1			13.8		24.7					6.8		52 4
28	13.6			1.0	31.8	5.6					22.5		74.5
29	1.0				1.0	0.2					4 9		7.1
30										15.0			15.0
31											6.5		6.5
Sum	223.1	51.6	226.8	14.8	59.4	80.1	11.1	3.5	0.0	.24 0	168.5	118.9	881 9

Dec. 1, 1861, to Dec. 1, 1862.

Day.	Dec.	Jan.	Feb.	Mar.	Ap	May.	June.	July.	Aug.	Sept	Oct.	Nov.	Total
1		2 2		23.5		0.3							26.0
2		19.6		13.5	0.9								34.0
3		1.4		13.1		5.3							19.8
4		0.9				4 6							5.5
5						5.3		5.3					10.6
6				4.2									4.2
7	0.2			17.7		0.4							18.3
8		3.2		1.5									4.7
9	1.7	0.8		12.6						2.7			17.8
10	6.7										1.5		8.2
11		1.5			0.1		0.2					1.0	2.8
12		1.3			11.0								12.3
13	24.2	0.9			2.2								27.3
14	1.0												1.0
15			17.1		2.3	14.8	0.5			4.8	8.5		48.0
16		0.2	15.5	22.8									38.5
17			16.3										16.3
18		2.1	35.7	13.1									50.9
19		5.1	34.9	31.5							2.2		73.7
20	1.4	25 8	0.7	9.5								9.4	46.8
21		0.4	17.6										18.0
22		4.9								14.2		2.5	21 6
23	3.2	32.2										17.4	52.8
24		1.6	19.6	15.5	0.6					8.3		16.1	61.7
25		0.4		5.6						0.6		0.2	6.8
26			14.7	4.9		0.8				0.2		1.4	22.0
27	15.8	11.4	17.6	10.2			0.6			5.8		27 2	88.6
28	3.4		0.2	6.3	0.1							8.8	18.8
29				5.3		0.3						6.2	11.8
30	1.0			17.4	3.3	2.4				4.2		14.7	43.0
31											19.0		19.0
Sum	58.6	115.9	189.9	228.2	20.5	34 2	1.3	5.3	0.0	40 8	31.2	104.9	830.8

LISBON RAINFALL.

Dec. 1, 1862, to Dec. 1, 1863.

Day.	Dec.	Jan.	Feb.	Mar.	Ap.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Total
1	6.6												6.6
2	22.1	1.3		4.0								1.6	29.0
3	18.7	24.8	0.3	41.0						1.9			86.7
4		34 4		24.8									59.2
5		2.0		2.1									4.1
6		9.0		12.3									21 3
7		1.1		0.6							1 4		3.1
8		3.0		8.2							1.8		13.0
9		24.2		4 8		0.1	1.8				19.5		50.4
10		1.3		8.0	0.2						11 8		21.3
11				1.2	0.6		4.6				2 2	1.0	9 6
12			4.3	1.1							17.3		22.7
13				7.7	2.2					8.6	1.0		19 5
14				0.1							4.4		4.5
15				1.0									1.0
16				0.5									0.5
17													
18						0 5							0.5
19										1.5			1.5
20						3,4							3.4
21					0.2	17.0		1.8		0.5		1.2	20.7
22						26.0		2.2		0.3			28.5
23						6 6				1.1	0.3	7.2	15 2
24		4.2				17 1				1.4			22.7
25					2.5	2.8	0.2			2.0	2.5		10.0
26							0.6		46 8		5.0		52.4
27									2.6				2.6
28							3.5		0.6				4.1
29	2.5												2.5
30	14.3	5.1								4.6	1.3		25.3
31		2.6									0.2		2.8
Sum	64.2	113.0	4.6	117.4	5.7	73.5	10.7	4.0	50.0	21.9	68.7	11.0	544.7

Dec. 1, 1863, to Dec. 1, 1864.

Day.	Dec.	Jan,	Feb.	Mar.	Ap.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Total
1				9.2			7.0				8.2	0.9	25.3
2											1.3	2.4	3.7
3				0.4			6.6				17.2		24.2
4				18.8			0.6				7.9		26.4
5				0 4									0.4
6				17.0							2.8		19.8
7		24.0	0.4	17.3		4.0					13.0		58.7
8		0.6	9.3	1.5		0.8							12.2
9		20 3	6.1	14.4		12.0					4.9	0.4	58.1
10			3 4	1.5		3.4						5.0	13.3
11		3.8			0.1								3.9
12		21 1			6.5								27.6
13					7.2								7.2
14					4.2		2.7	0.2				3.0	10-1
15					5.9					0.2		0.2	6.3
16		3 2			0.4					15.8		0.2	19.6
17		1.9		0.5							0.9	12.6	15.9
18				19.0						0.4	16.5		35.9
19				13.5							3.5	11.0	28.0
20				15.1	5.9						9.4		30.4
21				6 7	11.3						32.1		50.1
22			4.1	0.2	4.2				16.8		7.5		32 8
23			9.9	31.0	4.3						17.3	12.3	74.8
24			16.8			12.0					27.5	4.0	60.3
25			3.3	5.9		7.0					5.8	6.0	28.0
26			8.6		7.5	10.5				0.1	28.1	1.7	56.5
27			10.3	1.1						9.2	7.8		28.4
28			0.3							14.9	11.3	0.3	26.8
29			7.1								0.2		7.3
30										0.2	30.1		30.3
31	0.8					1.5					10.3		12 6
Sum	0.8	74.9	79 6	173.5	57.5	51.2	16.9	0.2	16.8	40.8	262.7	60.6	834.9

LISBON RAINFALL.

Dec. 1, 1864, to Dec. 1, 1865.

Day.	Dec.	Jan.	Feb.	Mar.	Ap.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Total
													19.3
1		9.0	7.9	0.1			2.3						4.4
2		0.5	3.5				0.4						16.4
3		0.1	4.4								11.1	0.8	22.5
4			4.1			2.2					16.2		18.4
5			0.8			11.4					0.6	5.6	73.9
6			5.6	1.1		11.2					50.6	6.0	72.5
7			10.4			26.4					35.7		59.0
8	9.1	1.7	6.5			11.0					30.7		106.8
9	6.2	22.1				6.9					11.0	60.6	33.7
10	3.6	0.4								10.2		19.5	14.7
11	11.9	1.6			1.0		0.2						56.5
12	3.2	37.8							1.0		3.3	11.2	60.8
13	31.2	0.5				25.9					2.1	1.1	35.8
14	23.8	1.2		0.4	6 9	3.0			0.5				8.7
15		0.1	1.9		3.6	3.1							18.1
16	5.6	4.8	4.6		3.1								24.2
17	9 6	5.3	1.2	0.1			7.8				0.2		43.8
18	0.7	7.9		13.9			4.3				17.0		19.0
19	2.4			2.7			1.0				0.9	12.0	51.3
20		35.5		6.6				1.0			7.2	1.0	51.9
21		13.4		2.1	4.0		3.4				20.5	8.5	11.0
22		0.1		0.8							8.2	1.9	36.9
23	0.4	18.3							1.6		0.8	15.8	8.1
24	0.4	7.3								0.4			51.8
25		9.3								1.5		41.0	4.7
26		0.8								1.0		2.9	28.3
27		8.8			4.9				0.2		0.1	14.3	12.1
28		2.1			0.8						1.8	7.4	41.1
29		6.0			5.0					2.7	0.8	26.6	23.6
30	7.5						0.7			12.8	2.6		13.1
31	0.9	10.2				1.0					1.0		
Sum	116.5	204.8	50.3	27.8	29.3	102.1	20.1	1.0	3.3	28.6	222.4	236.2	1042.4

Dec. 1, 1865, to Dec. 1, 1866.

Day.	Dec.	Jan.	Feb.	Mar.	Ap.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Total
1		4.6	3.4	9.3		7.3	1.5						26.1
2	3.3		7.4	14.2	3 2		0.7						28.8
3	12.2			13.7	1.2	2.2							29.3
4		6.3		2.2		34.5							43.0
5	5.7	1.9		3.5	9.8	39 5		2.4					62.8
6	14.3				2.4	6.6					1.0		24.3
7	3.6			3.7	0.9								8.2
8				0.5	0.4								0.9
9		0.6	5.3							2.6	0.4		8 9
10		7.0	0.7								7.2		14,9
11		14.4	19.7	1.0									35.1
12			5.9								1.8		7.7
13			2.0										2.0
14			6.5	4.8									11.3
15		0.6		16.4							0.6		17.6
16				11.2								3.2	14.4
17				21.4							17.7		39.1
18			1.6	17.6					1.0		2.9		23.1
19				5.8									5.8
20		9.4		12.9					0.3				22.6
21		1.2		0.3		0.5					7.4		9.4
22		0.4				4.0				4.2			8.6
23	14.6				4.3	23.3	0.2	1.3		7.5			51.2
24						1.7		0.6					2.3
25					1.0	0.8	0.2			0.1		0.9	3.0
26		0.6	10.8		4.5	0.5	0.1						16.5
27		10.0	16.4		23.3	0.7	6.3			3.7			60.4
28			16.0		2.1	6.2				0.3			24.6
29	5.5				32.2	0.5				2.7		8.8	49.7
30	0.8	1.2			1.0					0.3		9.0	12.3
31		0.8				12.2							13.0
Sum	60.0	59.0	95.7	138.5	86.3	140.5	9.0	4.3	1.3	21.4	39.0	21.9	676.9

LISBON RAINFALL.

Dec. 1, 1866, to Dec. 1, 1867.

Day.	Dec.	Jan.	Feb.	Mar.	Ap.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Total
1								0.3	5.9				6.2
2	6.8											0.2	7.0
3		0.7											0.7
4		4.1											4.1
5	0.2	7.9	0.2										8.3
6	0.1	3.2	1.0	13.3		2.2							19.8
7	0.1	8.1	0.2	26.4		19.1							53.9
8		15.8		5.1									20.9
9	0.3	0.9		2.4		0.4				0.2			4.2
10		19.4		6.3		7.3							33.0
11	0.4	1.9		4.3									6.6
12	0.2	9.2		2.5	0.8	5.4				10.1		18.9	47.1
13		1.6		14.9	1.8	5.4				0.9	0.4	12.6	37.6
14		2.5		12.0		1.4					5.2	54.4	75.5
15		1.2	2.9	0.6		0.8						48.8	54.3
16			22.7	0.2								6.2	29.1
17		23.4		5.6							0.2	12.5	41.7
18		7.8		12.7		2.2					0.2		22.9
19		14.0		12.3		0.1							26.4
20		18.9			7.2	0.1	0.7						26.9
21		0.1		5.6								0.1	5.8
22		1.4											1.4
23				6.9									6.9
24		7.5		0.7				0.3					8.5
25				1.3		4 3		6.4					12.0
26	0.8			11.2									12.0
27	4.6			5.2									9.8
28				1.4	1.0								2.4
29				2.8		2.2							5.0
30					0.8							1.2	2.0
31	7.1												7.1
Sum	20.6	149.6	27.0	153.7	11 6	50.9	0.7	7.0	5.9	11.2	6.0	154.9	599.1

Dec. 1, 1867, to Dec. 1, 1868.

Day.	Dec.	Jan.	Feb.	Mar.	Ap.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Total
1	24.0				2.4						1.8		28.2
2					0.7								0.7
3					17.5			0.1					17.6
4					0.4	27 6		4.3			4.9		37.2
5					2.0	0.6							2.6
6		10.5										3.9	14.4
7													0.0
8		0.8	20.0				0 3						21.1
9	3.4	0.5		2.0			0.1						6.0
10		0.3				0.6						9.3	10.2
11		13.7		3.0				4.8	0.4	4.2			26.1
12						0.2		1.9	2.8	0.5			5.4
13		8.3								3.3	0.7		12.3
14										12.7	5.9		18.6
15									9.7	0.2	0.8	15.8	26.5
16									1.9	15.6		7.0	24.5
17	0.1									0.4		14.6	15.1
18	0.2						2.7		8.4	22.5	2.0	3.0	38.8
19		5.0	2.4		5.4					5.2			18.0
20		4.5			4.0					12.4		1.0	21.9
21					0.4		0.1			1 6		2.2	4.3
22		5.8	0.8		3.5					0.7		24.3	35.1
23		0.3			4.8		0.2					2 0	7.3
24	4.4				1.8					8.5		0 5	15 2
25	16.4											9.8	26 2
26										7.5		3.5	11.0
27			0.3				0.3			2.4		0.4	3.4
28	8									0.8		1.0	10.6
29	2.0									10.4		1 4	13.8
30	15.2									16.4		38.3	69.9
31	15.2												15.2
Sum	89 7	49.7	23.5	5.0	42.9	29.0	3.7	11.1	23.2	125.3	16.1	138 0	557 2

LISBON RAINFALL.

Dec. 1, 1868, to Dec. 1, 1869.

Day.	Dec.	Jan.	Feb.	Mar.	Ap.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Total
1			6.0			0.2					5.0		11.2
2	23.5												23.5
3	0.4	7.7	0.2										8.3
4	5 2				0.2			0.2					5.6
5	1.1					27.9							29.0
6						16.4							16.4
7	0 2					5.4							5.6
8	1.5												1.5
9				3.2		14.9					6.2		24.3
10		12.3	0.1	3.5	1.4	0.2				1.8			19.3
11	5.8	1.3		7.1	0.7					5 6			20.5
12	62.7	17.0				17.9							97.6
13	13.0	0.6		10 7		0.2	2.3						26.8
14	2.3			7.0		0.4	0.3						10.0
15	16 7	1.4		0.1									18.2
16		0.2		1.1	3.3							1.0	5.6
17	15.8		1 3								14.1		31.2
18	0.2		8.2								7.6		16.0
19	3.2		0.5								0.5		4.2
20	15.5					0.3				1.0			16.8
21	2.8		7.0	1.1									10.9
22	5.8	1.0										1.5	8.3
23	0.2	0.8										4.1	5.1
24	13.3	2.0		0.3								1.3	16.9
25	3.0			0.4	0.5	3.9							7.8
26		17.7		0.4	0.2	3 4							21.7
27	3.4	9.0				0.6							13.0
28	0.3	5.0			1 4	0.7				5.0			12.4
29	6.3	0.2		0.5	19.4	3.2	0.3			9.2			39.1
30	0.3	16 0				0.4				1.9		0.2	18.8
31		5.3											5.3
Sum	202 5	97.5	23.3	35.4	27.1	96.0	2.9	0.2	0.0	24.5	33.4	8.1	550.9

Dec. 1, 1869, to Dec. 1, 1870.

Day.	Dec.	Jan	Feb.	Mar.	Ap.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Total
1		1.4							0.2				1.6
2		1.0	31.2	21.7							0.2		54.1
3	9.2	1.4	6 2	6.6									23.4
4			5.4	11.0			2.5				5.2		24.1
5		0.5		14.0						0.2			14.7
6	9 9	0.6	1.1	0.5		0.8				3.0			15.9
7	5.1		4.0	2.2	0.2					6.4			17.9
8	7.9	1.4	0.9	2 7	0.1						21.3		34.3
9	19.5		2.4	8.4							8.0	2.0	40.3
10		0.5	0.6		5.5						1.2	0.7	8.5
11	3.5		7.5					0.2			3.0	0.2	14.4
12			1.0			3.1					0.2	5.7	10.0
13	1.4	0.3	5.5						0.3			2.4	9.9
14	0.8	0.4											1.2
15	0.4	0.1	1.8								0.3	1.5	4.1
16			9 6										9.6
17	0.2		1.0		0.1				6.7		0.8	6.8	15.6
18					0.4					3.1		0.3	3.8
19	1.5		28.5						3.3	0.6		9.0	42.9
20	19.3				30.6							15.5	65.4
21	7.3									8.9			16.2
22	1.7		1.2									3.0	5.9
23	2.5		0.7								0.5	5.9	9.6
24			6.7								0.8	32.6	40.1
25			4.0									10.7	14.7
26	1.4	3 9											5.3
27	1.3	2.3	2 2		3.7							1.8	11.3
28			3.6									1.5	5.1
29		8.8											8.8
30	26.4	3.0							8.7				38.1
31	11.7	24.0											35.7
Sum	131.0	49.6	125.1	67.1	40.6	3.9	2.5	0.2	19.2	22.2	41.5	99.6	602.5

Remarks *on Hyrtl's Collection.*

(Read before the American Philosophical Society.)

Prof. Cope stated that this collection embraced 800 skeletons, each with the branchial apparatus mounted separately. A large proportion of the specimens measured two feet long and upwards. The Selachians were not very numerous. Among them was to be noted a saw-fish from the South Pacific Ocean. The Dipnoi were represented by two perfect specimens of the *Protopterus annectens* from Central Africa. The Crossopterygians were present in five specimens of *Polypteri*—some from Central, others from West Africa. Of Ganoids a fine series of *Lepidosteus*, Sturgeons, *Spatularia* and *Amia*.

The series of Nile fishes was probably the best in existence. The *Mormyridæ* were especially complete and represented by large specimens. There were two of *Gymnarchus niloticus*, each three feet in length. Many of the specimens were obtained at Chartum, in Nubia, others came from Gondokoro on the White Nile between lats. 4° and 5° N.

The Australian fauna was well represented. From it might be selected the genera *Schuettea*, *Neosilurus*, *Gadopsis* and *Parapistus*. Numerous species from Samarang, Singapore and Polynesia were included, and the *Osteoglossum formosum* from Borneo required especial mention. The ichthyology of Hindostan was well represented. The Mediterranean series was very complete. Among them was to be noted a specimen of the rare *Ruvettus speciosus*, three feet in length, one of *Trachypterus liopterus* still larger and an *Alepocephalus rostratus*. From the Canary Islands were some uncommon varieties, as *Nesiarchus nasutus* and *Centrolophus ovalis*.

The North American series was good, especially the *Catostomidæ*. There were numerous West Indian species, and a good representation of South American; chiefly from Chili, Puerto Cabello, Rio and the tributaries of the Amazon and Essiquibo. The latter were mostly from Natterer's collections, and embraced many forms of Siluroids, Characins and Chromids.

The specimens were prepared by Prof. Hyrtl himself, which was an unequalled guarantee of their completeness in all respects, to the most minute. The preparation of the supplementary ribs of the *Clupeidæ* (herring) was to be noted as an especially difficult task which had been successfully accomplished. The collection appears to have been commenced by Prof. Hyrtl not later than in 1850, and had been an object of interest to ichthyologists and anatomists for several years. It was probably the most valuable collection for study in this department in existence, and Prof. Cope thought it cause of satisfaction that it had arrived safely in the United States.*

* The liberality of Cope Brothers in transporting it free of charge from Liverpool to Philadelphia was acknowledged.

Prof. Cope remarked upon the peculiar features of some of the figures on the plates in Benzel's Reptilfauna der Gosau-formation.

Stated Meeting, November 17, 1871.

Present nineteen members.

Mr. Fraley, Vice-President, in the chair.

Mr. Phillips and General Tilghman, recently elected, were introduced to the presiding officer, and took their seats.

A photograph of Mr. Chabas was received for insertion in the Album.

Letters of acknowledgment were received from M. F. Chabas, dated Chalon sur Saône, Oct. 21, 1871 (Proc. 83, 84, 85); from the Linnean Society, London, Aug. 2 (xiv., i. 82, 83, 84, 85); and from the Smithsonian Institution (86).

A letter from the Linnean Society announced the sending of publications.

Donations for the Library were received from the Prussian Academy, the Montsouris Observatory, the Astronomical and Linnean Societies, the London Nature, the Boston Public Library and Dr. Samuel A. Greene, the Franklin Institute, the College of Pharmacy, the Medical News, the Penn Monthly, Mr. Latrobe of Baltimore, and the California Academy of Sciences.

A letter was received from Mr. Henry W. Field, dated Royal Mint, London, Oct. 22d, accepting his appointment to prepare an obituary notice of the late Sir John F. W. Herschel.

Mr. H. C. Carey read an obituary notice of the late Stephen Colwell, pursuant to notice.

The death of John Edwards Holbrook, M. D., formerly Prof. Anat. Med. Coll, South Carolina, which took place at Norfolk, Mass., Sept. 7, 1871, was announced by the Secretary.

The death of Ed. W. Brayley, F. R. S., Feb. 1, 1870, was announced by the Secretary.

A memoir for the Transactions: On the Tours of the Chess Knight, by M. Serge de Stchoulepnikoff, was received, with a letter from the author, dated Circleville, O., Nov. 3, 1871, and, on motion, referred to the following Committee; Prof. George Allen, Mr. Pliny E. Chase and General Tilghman.

A Note on the Footmark in Hieroglyphic Script, by M. F. Chabas, of the Institute of France, was read by the Secretary.

Note of F. Chabas, of the Institute of France, on the Foot-mark in the Hieroglyphic Script.

I find in the Proceedings of the American Philosophical Society (Vol. XI., p. 312) the following statement:

"Mr. Lesley referred also to the fact that the ancient Egyptian B was graphically represented by the leg, A by the arm, T by the hand, and that what is called the comb may have been meant for the foot-mark."

I am not acquainted with any hieroglyphic character bearing in its graphical form a nearer resemblance to a comb than [Mr. Chabas here gives the M as in the first King's name, Mena,] the larger drawings of which show manifestly to be a chess or draught-board with its men.

But the feet occur in the hieroglyphic script, not with a phonetic but with a symbolic worth. They are a mark of the actual presence of the delineator. When a pious Egyptian repaired to some place of worship, in a distant country, he would sometimes, as a token of his zeal, incise a figure of his two feet on some stone in the neighborhood. Similar sculptures were observable on the terrace of the temple of Khons at Karnak, and have been published by M. Prisse d'Avennes; the name, pedigree and titles of the pilgrim are generally written close to his sculptured feet, which are represented either naked or shoed; in one case they are replaced by the soles or feet-marks.

This practice was probably very old, but either from the scarcity of monuments or the neglect of observers, it can not be traced up in the first empire. One of the instances published by M. Prisse refers to the reign of Apries.

F. CHABAS.

Chalon sur Saône, Oct. 21, 1871.

Mr. Lesley explained that he referred to the comb-like syllable *Kam* which occurs frequently with the signification "black; to become black," and therefore, as the name of Egypt *Kam* "black land," the *HaM* of the Hebrew Scriptures. Its verbal meaning is "to advance or be advanced to completion," and is so used in reference to any work, building or monument. Although the figure is drawn with a square heel, yet the slant of its front end, and the setting upon it of five points like toes suggests a plausible explanation of its meaning *to advance*, provided it be allowed to represent the human foot, which otherwise does not appear in Egyptian, except in profile and in connection with the leg. Why Bunsen should call it the tail of a crocodile it would be difficult to explain. Dümichen's plates of the legends on the walls of Dendereh do not give the figure on a scale large enough to decide upon its original shape, and I have never happened to see it on the monuments.

Mr. Cope presented for publication in the Proceedings, with four octavo plates, a communication on certain extinct vertebrata in the strata of North Carolina; and illustrated a sketch of his paper by exhibiting some of these fossil remains.

The Minutes of the last meeting of the Board of Officers and Council were read.

Pending nominations Nos. 679, 680, 681, and new nomination No. 682 were read.

Mr. Fraley reported that he had duly executed the Power of Attorney in the case of the Michaux legacy and transmitted the same to M. Carlier.

The request of Dr. Somers, Prof. Chem. Southern University at Greensboro, Ala, was referred to the Committee on Publication, and the meeting was adjourned.

Obituary Notice of STEPHEN COLWELL.

(*Read before the American Philosophical Soc., Nov.* 17, 1871.)

BY HENRY C. CAREY.

A life protracted considerably beyond the allotted threescore years and ten has brought me, in the course of nature, to the position of survivor to a host of personal friends whose lives had made them worthy of the remembrance in which they yet are held by those who had known them best. Of one of the worthiest of those whom I have familiarly known, and for their words and their works have most esteemed, it is that, in accordance with the request with which the Society has honored me, I have prepared the brief memoir that will now be read. For its preparation and for the proper performance of duty to the departed, to his surviving friends, and to the public which has a property in his memory, I claim to have little qualification beyond that resulting from long and familiar acquaintance; from a fellowship in the public labors to which were devoted so many of his life's best days; and from an earnest desire to aid in perpetuating the recollection thereof in the minds of those whose service such labors had been performed.

An ardent pursuit of the same general course of study, in a yet unsettled department of inquiry, tends necessarily to the development of difference in modes of thought, even where, as has been the case with Mr. Colwell and myself, the end in issue is substantially the same. Between us, however, there has never been any essential difference, and while it has been among the highest gratifications of my life, it has not been least of the assurances that have sustained me in my own course of speciality of labor, that his views of social and economic theory have so nearly coincided with those which I have been led to form.

This general coincidence of doctrine is here offered as a reason for avoiding that indulgence in eulogy of his literary labors which so justly is their due. A still stronger reason for preferring to allow the simplest and plainest history of his works to indicate his worth, is found in that modesty which constituted so striking a feature in his character, respect for which forbids that I should here say of him anything that would have been unacceptable if said in his bodily presence. That I can entirely restrain within these limits the expression of my apprehension of his character, and of his life's work, I do not say; but that I feel the repressive influence of this regard correspondent with the habitual deference which has throughout many years of intercourse governed my demeanor towards him, is very certain. Further than this, however, it will be enough for praise if I can succeed in making this memoir an adequate report of his active and energetic life.

Having thus explained the feelings by which I have been influenced, I

shall now proceed to give such facts as have been attainable in regard to his unwritten history, and such indices of the works he has left behind him, as seem to claim a prominent place, and can be made to fall within the compass of the brief time allowed me for their presentation.

STEPHEN COLWELL was born in Brooke County, West Virginia, on the 25th of March, 1800. He died in Philadelphia on the 15th of January, 1871, having nearly completed his 71st year. He received his classical education at Jefferson College, Canonsburg, Washington County, Pa., where he graduated in 1819. He studied law under the direction of Judge Halleck in Steubenville, Ohio; was admitted to the bar in 1821; practised the profession seven years in St. Clairsville, Ohio; and in 1828 removed to Pittsburgh, where he continued so to do until the year 1836.

Indicative of that ability and industry which marked his whole subsequent life, and now so well accounts for the mass and quality of his attainments, are the facts that he graduated at the early age of nineteen, and entered upon his profession at twenty-one.

The practice of the law, however, was not the sphere of mental activity for which by tastes and talents he had been best by nature fitted. The study of this science was, nevertheless, a happy preparation for the inquiries in whose pursuit he afterwards became so much engrossed. Its exacter method, doubtless, corrected the mental habitude and the narrowing influence which an ardent mind is apt to catch from an exclusive devotion to the study of any single branch of literature or science. His writings everywhere bear witness in logic and diction to the corrective influence of his legal acquirements. Social science is that department of knowledge which especially receives its verification and practical adjustment in jurisprudence and civil goverment applied—the philosophy of Law being the crown and summary of sociology in all its branches.

Further, Mr. Colwell gave for a layman an unusual amount of study to the department of religious literature, and here also we find the guiding influence of his sociologic as well as of his legal training. A devoted religionist from earliest youth to the close of life, he gave himself to an ardent study of doctrine and of duty, meanwhile laboring as zealously and almost as constantly as if he had filled the office of pastor in the Church, in the propagation of such opinions as demanded conformity of life from professors of religion. His publications bear witness of his faithfulness, as his life in its every relation illustrated the morality and the charity which his faith enjoined.

It is not for us to sit in judgment upon religious doctrines, whether to applaud or to condemn them. His well known zeal, and his abundant labors in piety and charity, are here adduced for the simple reason that the portraiture of the man would be incomplete and most unworthy of its subject without distinct recognition of a feature so predominant in his character.

Were I here to venture an opinion, fully warranted perhaps by the subject, I should be disposed to say that the study of the theologian must

be greatly influenced for safer direction and better uses when held in logical harmony with, and restrained of its speculative tendencies by, those rules of thought which must govern men in the actual duties and relations of life. To my mind it is clearly obvious that the religious writings of Mr. Colwell exhibit a healthy tone and a useful drift reflected from his economic studies; and in these latter a faithfulness of service and a dedication of spirit and endeavor, which happily illustrate the moral responsibility resulting from the sentiments of the former. To this I may perhaps be allowed to add, that if each and every man occupying an influential position could be induced with equal fidelity and ability "to show his fidelity by his works," the prevailing indifference to the claims of Christianity would speedily give place to a widely different spirit induced by the attractiveness of its illustration. Here, however, I am engaged mainly with the prominent traits of Mr. Colwell's own character and the influences that formed his life and gave direction to it. His education and effective development were not found alone in the studies by which he was so largely and so usefully occupied. Whatever of principle and policy resulted from the application of the student was induced and enriched and energized in another and even more exact training school than any that the speculations of science can afford. In the thirty-sixth year of his age, fresh and full of all that reading and reflection could supply, he entered upon the conduct of business affairs in an occupation that as much as any other, and probably even more, brought into service and severely tested both economic facts and principles. He became a manufacturer of iron first at Weymouth, Atlantic County, New Jersey, and afterwards at Conshohocken, on the Schuylkill. Throughout a quarter of a century of vicissitudes, inflicted upon that department of manufacture more mischievously than upon almost any other by an inconstant and often unfriendly governmental policy, opportunity was presented, as the necessity was imposed, for studying the interests of productive industry in the light of such actual and greatly varied experiences as might instruct even the dullest, and could not fail to teach one already so well qualified for promptly understanding all that actually concerned that and every other branch of industrial production. Before entering upon the arduous and trying experiences of this pursuit he had visited Europe, and there had studied the art and management of its advanced and varied industries.

The settlement of the large estate of his father-in-law, the late Samuel Richards, and the administration of those of several other members of his family, required and received as much attention during many years as would have constituted the entire business of many men, who would have thought themselves fully occupied. In addition to private affairs, so considerable and so exacting, he was constantly engaged as a leading and working member of various public associations; industrial, benevolent and educational. The character, the extent and the variety of these engagements, to which he was invariably attentive and punctual, may be

inferred from a simple enumeration by their titles, as follows: he was a working member of the American Iron and Steel Association, from its origin to the close of his life; an active member of the African Colonization Society for more than a score of years; several years engaged in the management of our House of Refuge; nearly twenty years a Director of the Camden and Atlantic Railroad, whose Board of Directors, in a feeling notice of his death, say that, "having been an active member of the Board from its organization, and having contributed very largely of his means, time and labor in the prosecution and completion of this work; in many dark periods of this enterprise we could always look to Mr. Colwell for his matured judgment and able counsel."

He was a Director in the Reading and in the Pennsylvania Central Railroads, and for years held the office of a Trustee of the University of Pennsylvania; as also a similar position in the Princeton Theological Seminary. Simultaneously therewith, he was one of the Trustees of the Presbyterian General Assembly, and member of the Board of Education of the Presbyterian Church. After the close of the Rebellion he gave large pecuniary assistance, and his usual energy of service, to the Freedman's Aid Society, as during the Rebellion he had contributed with like liberality to the work of both the Sanitary and Christian Commissions. Of his services in these great patriotic charities a gentleman well acquainted with their history says: "At the breaking out of the Rebellion he felt deeply for the distress in the camps and on the battle-field, and it was at his suggestion that the first man who left his home to assist the helpless and the wounded, took his way to the seat of war. He also contributed freely to supply comforts to those in the hospitals. To one of the active stewards he said, 'Let nothing be wanting, and if the Government funds are insufficient I will see that the bills are paid.'" The same witness of his active benevolence to the suffering soldiers, and of his personal demeanor in its administration, further says: "Those who accompanied him on his visits to the Army of the Potomac, can never forget the kindness and respect with which he treated the humblest individuals."

In the patriotic services and sacrifices to which the country called its best citizens in the hour of its utmost need, he was in every form of duty, one of the earliest most constant, persistent and efficient of the men in private life who gave themselves unreservedly to the salvation of the Union. The Union League of this city in words which well might serve as a condensed memoir of his life and character, bears this testimony to his agency in the great work of their association: "With an intelligent and thoughtful mind, fully convinced of the necessity and usefulness of such an organization, and a heart warmly alive to the encouraging influences, it was peculiarly fitting that at the first formal meeting which led to the establishment of the Union League should be called upon, as he was, to preside. His name thus heads the list of signers of the constitution of the League; and he grew with its growth, ever in the forefront of whatever movement was planned for giving aid and comfort and

support to his country and its government throughout the course of its struggle for existence, in resisting, by force of arms, a causeless and wicked armed Rebellion." Of his personal character and demeanor, they say: "We desire to bear testimony to those virtues which manifested themselves in all its intercourse with us; to the singleness and unselfishness of his purpose; to his courteousness and urbanity in our varied relations; to his firmness, cautiousness and wisdom in the deliberations of our councils; to his patience, unwearying industry and cheerful devotion of time, abilities and means in aid of the cause so dear to all our hearts; to his constant unwavering joy, and faith, and trust in the overruling Providence of the God of our fathers amid the darkest hours of the country's peril, as well as in times of success and victory."

Such engagements as these, and numerous others kindred in their character and calling for similar labors, filled the middle and later periods of his life with occupation: his associates, and all with whom business intercourse and public enterprises connected him, testifying to the prompt, energetic, patient and worthy performance of every duty thus assumed or imposed. Nearly half a century employed in public and private affairs making large demands for labor and care, and involving great responsibility, gave him that sound practical experience which well and effectively woven into the studies of his life made him what he eminently became, a clear, safe, and thoroughly instructive economist. Concurrently with this practical training he was, in the best sense and fullest meaning of the word, a student. As early as his business life began, if not even earlier, he commenced the collection of a library of social science, political economy, finance, pauperism, organized charities, productive industries, and associate and cognate departments of science, now the largest and best to be found in the country. This grand collection has not been catalogued, or even classified, but it considerably exceeds five thousand volumes, and is estimated for the purpose of insurance at a value of twenty thousand dollars. To this library and to the books, pamphlets, periodical and newspaper articles of his own production, he devoted all his leisure. In several lists of cited authorities appended to his own publications and criticisms upon them, he furnishes evidence that he was, in the language of one of his familiar acquaintances, "one of the greediest of readers."

To the commonly accepted authorities on Political Economy, Finance, and Policy of Public Affairs, he, however, gave no more than that amount of faith and acceptance which they should command from a mind well stored with the facts and philosophy of their subjects. To a friend who expressed surprise at his vast collection of books and pamphlets on the single subject of Money, he replied when asked if he had perused them all, "enough to know that there is really little or nothing in them of any value."

His library, besides its completeness in standard works, derives a special value from its collection of over twenty-five hundred pamphlets on topics

usually embraced in what is called Political Economy; each separately bound and capable of classified arrangement. He regarded, and justly too, such smaller treatises as especially valuable for containing the best thoughts of the writers in the most condensed form, and likely thus to secure not only the greatest number but the most attentive readers. For the most part he put his own publications on social and economic subjects into this unpretending form.

His judgment was too clear and too well poised to suffer the imposture of pretentious authorship. Knowing that book-makers are not always thinkers he gave his regards to those writers only who had something of their own to say, or knew how to give effective array to the valuable words of others. It would have been an excellent service to students, now abandoned to their own unformed judgment in the selection of works in this department, and thus condemned to promiscuous reading, if Mr. Colwell had in some effective way employed his eminent discernment in giving us an *index expurgatorius* of the books and treatises upon economic subjects which crowd our libraries, thus driving a stake through the worthless and the false among them, numerous as the latter are. In his Essay Preliminary to List's Political Economy, he has, indeed, shown his eminent capacity for estimating aright the economic authorities of their true value, confining himself, however, almost entirely to an analysis and commendation of those works which are worthy of reliance. It was more consonant with his taste and tendencies to select the good, than to annoy himself with the study and exposure of that which was calculated to be injurious. Often have I wondered at the patience, even more than at the diligence, great as it was, with which he conscientiously surrendered so large a portion of his months and years to library labors. His toil, however, was made for excellent uses, and the fruits of his literary industry exhibit themselves not only in the number but also in the value of his publications. Of that value but little can be traced to the thousands of volumes which had passed through his hands. Indeed, it is curiously significant that the best read man in economic literature stands now before us so little indebted to the books of his predecessors for the most valuable portions of his own productions. Never writing without having something worthy to be read, all that he did write was, as largely as can be affirmed of any other prolific author, in matter and manner his own. There was in him, however, nothing of arrogance, nothing of the scorner. In the whole course of his literary pursuits may be discovered a constant effort to promote and propagate important scientific truths bearing upon social welfare, under cover of such books as seemed to him to deserve extensive circulation. To the translation, annotation, and effective distribution of these he freely and devotedly gave his time, his labor, and his means. Among the leading instances of this kind, is the translation, by Mr. Matile, of List's National System of Political Economy, with his own invaluable Preliminary Essay, above referred to, and with copious marginal notes upon the text, from his own pen. In like

manner he procured the translation (again by Mr. Matile) and the publication for liberal distribution, of Chastel's "Charity of the Primitive Churches;" and also the republication of "The Race for Riches," by William Arnot, of Glasgow, with a corroborative preface and notes, by himself supplied.

This would be the place for giving special attention to that long and varied catalogue of his own contributions to the literature of political economy, finance, charity, and Christian ethics, in the form of pamphlets and essays, and other articles in the reviews, periodicals and newspapers. With that detail, however, I will not here task myself nor use the passing hour of your time, preferring to append hereto a list of his works as full and complete as I have been able to make it. Mr. Colwell, as his family inform me, neither collected nor registered these productions, as a consequence of which my summary of them by their titles is necessarily incomplete, although not otherwise incorrect.

His labors of mind and pen, his endeavors, services, and subsidies in aid of the establishment and extension of collegiate education; his personal pressure upon all who were in the way of forwarding the great enterprise; his donations and legacies, all had this one grand leading aim—the propagation of sound doctrine in social duty, and its enforcement in the education not only of our scholars, but also of the reading people of our great community. To that object he dedicated his library in giving it to the University of Pennsylvania. Anxious to make the gift more effective, he coupled the grant, in his deed of trust, with a condition that required the endowment of a chair of social science; but his family, knowing his intention that the donation should in no event prove a failure, has waived the present performance of the condition, in the well warranted expectation that in good time it will be carried out.

With the like intent he labored long for the establishment of a professorship in the Theological Seminary of Princeton, an idea that, with the assistance of others in great measure brought to contribute by his own perseverance and his liberal advances, has now been carried into full effect. "His works do follow him"—the inauguration, on the 27th of September last, of a professorship of "Christian Ethics and Apologetics," in its promise fulfilling one of the dearest wishes of his heart.

What Mr. Colwell intended by the establishment of a chair of Christian Ethics, in Princeton, and what he regarded as the chief object of a chair of Social Science in the University of Pennsylvania, can scarcely be misunderstood if his own writings be studied for their ruling sentiment and leading purpose. Cultivating political economy as a theory of beneficence, he wrote his most elaborate and voluminous work upon the credit system, embracing therein all the agencies and instruments employed in foreign trade and domestic commerce, and gave a vast amount of time and thought to the literature of these several subjects in all their branches; but through all and over all the crowning aim and purpose of his endeavors stands out conspicuously, crystallized as it is in a definition of political economy in which, after reviewing the entire range of conflicting

explications, he says: "When we meet a definition running thus—the science of *human welfare*, in its relations with the production and distribution of wealth, we shall begin to hope the doctrine of social, or political, or national economy, is beginning to assume its proper proportions." The sentiment of that definition directed all his studies, all his writings, and, as a passion, governed all his life. In religion, the faith that *works* by love; in economic theory, the best interests of humanity; in morals, the justice, mercy, and charity which practically exemplify the brotherhood of men; were the governing impulses of all the works of both his head and his hands.

In his "New Themes for the Protestant Clergy" we find such sentiments as these: "Creeds, but not without charity; Theology, but not without humanity; Protestantism, but not without Christianity." Again: "It is not enough for the Christian to be concerned only for the interests of men in the world to come, but for their best interests in this world." With some severity of rebuke, but far more earnestness of affection, he says: "We maintain that Christ himself should have the chief voice in defining Christianity, and that this has been denied him in most, if not all, the compends and summaries of Christian doctrine which are the bond of Protestant churches;" following this up by urging the fact that "the world now believes that the religion announced by the Author and Finisher of our faith embraces humanity as well as divinity in its range."

This remonstrance, and its implied censure, will be understood when we perceive that he went further, far further, in his apprehension of true Christian charity, than almsgiving extended to pressing cases of distress. The modern usage of devolving the relief of the poor upon the poorhouse system established by the civil law, he calls "the stigma of Protestantism;" and he demands from the professors of Christianity an earnest endeavor to give the poor *permanent* emancipation from the evils which they endure. He presses the charge against the Established Church of England, that it holds resources donated to its Catholic predecessors for relief of the poor, which now yield £50,000,000 per annum, while throwing the support of the suffering upon the charity of the State; at the same time quietly sustaining that system of industrial and commercial policy which takes from the labor of the realm two hundred and fifty millions of dollars for the use of the government, and five times more for the profit of capital. Nay further this gentlest of gentlemen, this most orthodox of churchmen, this most devout of worshipers, in the conviction that the failure of Christians to exemplify Christianity in their dealings with the world is the grand cause of the aversion and rejection it encounters, is led therein to find some justification for the socialism and the insurrectionary demonstrations now so rapidly and threateningly spreading throughout Europe and America, and exhibiting such a spirit of revolt among the masses of Christendom as is nowhere found in the pagan world.

In the battle-cry of the reformers now advancing upon the conservatism of our civilization, he hears the proclamation of "the fatherhood of God and the brotherhood of man"—a protest against "that notion of individual liberty which leaves every man to care for himself, and ruin to seize the hindmost."

To the almost universally prevalent doctrines of political economy he traces the apathy, indifference, and even hostility of the fortunate classes to the duties enjoined in the second table of the law, as it is summarized by the Great Teacher. Singling out the most distinguished and most popular of now existing disciples and advocates of the *laissez-faire* school of economists, he thus exhibits Herbert Spencer's "Social Statics": "The man of power and the man without; the man of wealth and the pauper, should each have the largest and most perfect liberty consistent with their not touching each other. * * * It forbids the thought of charity, or brotherhood, or sacrifice; it consecrates selfishness and individualism as the prime feature of society. * * * Its principle is the least possible restriction, the fewest possible enactments; the weak must be left to their weakness, the strong must be trusted with their strength, the unprotected man must not look for favor, and government must resolve itself into the lowest possible agent of nonintervention."

Than the view thus presented of the now-so-much lauded Spencerian social philosophy nothing could be more thoroughly accurate. The whole tendency of that modern economical school, to whose teachings our departed friend was so much opposed, has been, and is, in the direction of giving increased power to the rich and strong, while throwing responsibility on the shoulders of the poor and weak. "If the latter *will* marry, and *will* have children, why," say they, "should they not be allowed to pay the penalty of their crime, as so many millions of starving Irish have already done?" "Why," though in somewhat different words, now asks Mr. Spencer, "Why should not the poor remain in ignorance if unable to provide for educating their children and themselves?" "Why should the millionaire be required to aid in maintaining hospitals in which damage to poor laborers' limbs may promptly and properly be repaired?" "Is it not for every man to do as he will with that which is his own?" The new philosophy having answered this latter question in the affirmative, need we be surprised that the miserable selfishness thus given to the world as science should have excited the indignation of one who knew, and felt that it must be a mere pretence of science that could sanction any course of conduct so wholly inconsistent with the divine command, "that we do to others as," under similar circumstances, "we would that they should do to ourselves?" Assuredly not!

It would be difficult for me fully and completely to express the strength of the humanitarian sympathies exhibited in Mr. Colwell's plea for justice to the victims of our reckless competition and our voracity in the pursuit of material wealth. To prevent misconstruction of his severe animadversions upon the existing agency of church and state in the prevailing disorders of society, and to show the bearing of his complaint I

cite another passage from the "New Themes," as follows: "The doctrine that property, real and personal, must under all circumstances remain inviolate, always under the ever-watchful vigilance of the law, and its invaders subject to the severest penalties of dungeon and damages, may be very essential to the maintenance of our present social system, but it totally disregards the consideration that Labor, the poor man's capital, his only property, should, as his only means of securing a comfortable subsistence, be also under the special care and safeguard of the law. The doctrine that trade should be entirely free—that is, that merchants should be perfectly at liberty, throughout the world, to manage their business in that way which best promotes *their* interests—may suit very well for merchants, making them masters of the industry of the world; but it will be giving a small body of men a power over the bones and sinews of their fellow-men, which it would be contrary to all our knowledge of human nature if they do not fatally abuse, because they are interested to reduce the avails of labor to the lowest attainable point, as the best means of enlarging their business and increasing their gains. That philosophy," he continues, "which teaches that men should always be left to the care of themselves—that labor is a merely marketable commodity which should be left, like others, to find its own market value without reference to the welfare of the man, may appear plausible to those who forget the fatherhood of God and the brotherhood of men, but is utterly at variance with the precepts of Him who taught that those who stood idle in the market-place because no man had hired them, and were sent to work at the eleventh hour, should receive the same as those who had borne the burden and heat of the day."

It is not my business here and now either to commend or to impeach, but simply to state the attitude assumed by Mr. Colwell in reference to questions so much exposed to debate as these, and by him so sharply and earnestly treated. The great sensation produced in our religious world by their publication has given way to much more moderate feelings, and evidently enough to a better appreciation of their spirit and design. One of the representative papers of the church of which he was a life-long member, thus speaks of the controversy which his publications had aroused ten years since: "In one or two of his own books on this engrossing and all-important theme [Christian charity], he used language in regard to the apathy and criminality of modern professors of faith in Christ and his salvation, which was so severe as to arouse bitter hostility to his faithful and well-meant efforts. Would that now, when the mutual wounds have ceased to smart, in the case of most of those engaged in them, alas! by a departure from all the conflicts of the church militant, earnest men could be roused to examine their lessons and suggestions, forgetful of the occasional sharpness of the form in which they were conveyed." The most aggrieved having thus now come to acknowledge that "faithful are the wounds of a friend," they may also recollect that only once, and that in a strikingly pertinent instance, the founder of their faith is reported to have

given way to indignation against a piety that subordinated humanity to theology. "When the rulers of the synagogue watched him whether he would heal the withered hand, in their church, on their Sabbath-day, he looked round about on them with *anger*, being *grieved* for the hardness, or, as the margin has it, the blindness, of their hearts." (Mark iii. 2–5). That it was this sort of indignation, mixed with the same kind of grief, which induced the severity of remonstrance complained of at the time, is manifest in the whole tone, and yet more so in the special drift of his objurgations. The true construction of his aim, indeed, is found in his protest against the ruling doctrines of political and social economy which the churches, in common with the community, accept. A single sentence well represents him on this subject, as follows: "The social, political, and commercial institutions of the present day, founded upon, and sustained by, a selfishness heretofore unequaled, are the great barriers to the progress of Christianity." And again: "Political economy, strictly so called, is as much opposed to the spirit of Christianity as it is antagonistic to socialism; or, in other words, there is far more in common between socialism and Christianity than there is between the latter and political economy." The system of economic theory by himself adopted, is of course not the one intended here, but is that one which, referring to the North British Review, is thus described: "Followed out to the utmost, the spirit of political economy leads to the fatal conclusion—that the conduct of the social life should be left entirely to the spontaneous operation of laws which have their seat of action in the minds of individuals, without any attempt on the part of society, as such, to exert a controlling influence; in other words, without allowing the State or institutions for general government any higher function than that of protecting *individual* freedom."

It is, therefere, the *laissez-faire* theory of political economy which thus is charged with hostility at once to Christianity and humanity. The buy-cheap-and-sell-dear system elsewhere described by him as a policy "in trade and in society, which makes it not only the interest, but the natural course of every one to prey upon his fellow-men to the full extent of his power and cunning, and is well fitted to carry selfishness to its highest limits, and to extinguish every spark of mutual kindness." His political economy was a system of philosophic benevolence, a doctrine of justice, mercy, and truth, with a resulting economic policy of protection to productive industry, leading to the highest human welfare. In the appendix and notes to his second edition of the "New Themes," he has given us a whole library of the literature of Charity. In the hundreds or treatises there cited and briefly epitomized, he exhibits a breadth of survey and depth of inquiry that one would think must exhaust the subject. It was the result of many years of labor, directed by a zeal that nothing could inspire and sustain but a heartfelt devotion to the work of social duty and remedial beneficence. May I not here add, as a reflection that concerns the students of social science, that the system of economic doctrines which secured the assent of a mind so fully informed, so eminently

endowed, and so long and zealously devoted to a search after truth, is entitled to all the confidence that authority can give, and justly claims most studious attention.

Having rendered his best personal services to the subject which he had so much at heart, he further evidenced his earnestness and solicitude for its still more formal and more adequate treatment by offering a prize of $500 for a treatise upon the law or doctrine of Christian charity, accompanying the offer with a general outline directory of the plan of the required work, indicating its essential points; among which are to be noted the organization of labor; international trade in its effects upon the rewards of domestic labor; the subject of public education; the law of charity as applying to the poor, the suffering, the imprisoned, the vicious, the insane, the intemperate, the dangerous, &c., &c.

I am not aware that any work of real merit was secured by the liberal reward offered. No such book having been published, it is presumable that no response was made.

There remains yet to be considered, in such manner as my limits allow, another and a highly important division of the service rendered to the public by Mr. Colwell, in an official position to which his high reputation called him in the 65th year of his age. In June, 1865, he was appointed upon the Commission, authorized by Act of Congress, "to inquire and report upon the subject of raising by taxation such revenue as may be necessary in order to supply the wants of the government, having regard to, and including the sources from which such revenue should be drawn, and the best and most efficient mode of raising the same." In the service imposed by this appointment he continued till the midsummer of 1866, when the work assigned was finished and fully reported. The labor thus undertaken and performed interrupted and even ended the active literary pursuits and practical work of his life. His family, whose tenderly affectionate watchfulness makes them the best and most competent witnesses, attribute to his exacting and exhausting toil in the duties of this position that failure of his health which soon afterwards obliged him to relinquish, in great measure, his life-long pursuits both as student and as writer.

In the Report of the Revenue Commission, communicated to Congress in January, 1866, and published in a large octavo volume by authority of the House of Representatives, may be found the special reports of Mr. Colwell on "The Influence of Duplication of Taxes upon American Industry—upon the Relations of Foreign Trade to Domestic Industry and Internal Revenue--upon Iron and Steel—and on Wool and Woolens." Two other reports of his, one upon High Prices and their Relations with Currency and Taxation, and another, upon Over-importation and Relief, are not included in this volume. How he executed the work which fell to his share of the duties of the Commission, it is enough to say that *he* did it to assure us of finding therein the fullest discussion of those vastly comprehensive subjects, based upon the most ample store of statistical facts, and arrayed with that force which the soundest theoretical princi-

ples, and the largest practical acquaintance with the details which enter into the several subjects of inquiry, alone could give.

The work done by him, outside of that which his own pen has reported, was of itself, and independently, worthy of permanent record. The Secretary of the Wool Manufacturers' Association, Mr J. L. Hayes, an eminently capable witness, thus speaks of his agency and influence in harmonizing the conflicting interests of the agriculturists and manufacturers of this staple industry of the nation: "The conferences between the two committees (representing the respective parties) commenced in January, 1865, and were continued without much pause for six months. At the outset the two committees were widely apart in their views, and the traditional jealousies became at once apparent. Here the weight of character disinterestedness, and moral power of Mr. Colwell came into play. He was personally present at many of these conferences, and I am convinced that the harmonious arrangement finally made was mainly due to his influence. This influence was perfectly unobtrusive, but both parties had absolute reliance upon Mr. Colwell's integrity and wisdom, and a mere hint from him was sufficient to give a right direction to our councils. Some of the suggestions which he made were of great practical value." Of one of these this gentleman says: "It has been in operation five years, and it is a constant surprise to manufacturers and growers that so brief an act, affecting so many really distinct branches of industry, should cover so much and operate so wisely." Again he says: "The bill, of which the chief features are due to Mr. Colwell's suggestions, is wonderfully sustained; its practical working is really remarkable for its success, * * * but the influence upon our own industry is by no means the chief object. The wool tariff is the key to the protective position in this country. It secures the agricultural interest and the West."

His treatment of this subject, and the reports upon trade, production, prices and national finance, place him, in my judgment, highest among the authorities in our history in whatever combines knowledge of facts and soundness of economic principles. Quite sure am I that there is not so much of practical value and guiding principle to be learned even in that great storehouse of economic literature which he has given to the University. The earnest and intelligent student of the industrial and commercial policy of our country who may give to these reports the attention that is their due, will find himself prepared for a safe, clear and satisfactory judgment upon all of the many questions therein embraced.

Incidentally, but necessarily, intermixed with the history and statistics of our national industries, an unusually effective examination of the theories of free trade and protection finds a deservedly prominent place in these reports; and the predominant claims of labor upon the care of government and the regard of the community is the pervading spirit and ruling impulse of all that he here has written. His heart was in this matter, and his philosophy most happily corroborated his philanthropy. The key to all his economic doctrines is in such simple self-proving propositions as these: "The highest condition of national welfare depends upon

the highest condition of the masses of the people in point of morals, religion, intelligence, social ease, and comfort." "The industry of a nation is an interest so vital as to be equaled only by its internal liberties and its independence of foreign control. As the tendency of full employment is to exclude crime, the benefits of that high integrity which is the best cement of society, may be expected to reward a nation in which occupation is the most varied and labor best remunerated."

Last to be noticed, although not latest in its presentation to the world, is Mr. Colwell's highly valuable work on money and its substitutes, credit and its institutions, entitled, "*Ways and Means of Payment: a full analysis of the credit system, with its various modes of adjustment.*" Its essential object is that of laying the axe to the root of that pestilent heresy which teaches that prices are wholly dependent on the supply of money; and that, to use the words of Hume, the only effect of an increase in the abundance of the precious metals is that of "obliging every one to pay a greater number of those little white or yellow pieces than they had been accustomed to do." The whole question of prices is here discussed with a care characteristic of its author; and his readers, however they may chance to differ from him in regard to details, can scarcely fail to agree with him in the belief he has here expressed, that "among the innumerable influences which go to determine the general range of prices, the quantity of money or currency is found to be one of the least effective." Truth, however, as is well known, travels but very slowly through the world, centuries having elapsed since demonstration of the fact that the earth revolved around the sun, and four-fifths of the human race yet remaining convinced that the sun it is that moves, and not the earth. So has it been, and so is it like to be, in the present case, the most eminent European economists still continuing to teach precisely what had been taught by Hume, and statesmen abroad and at home still constructing banking and currency laws under the belief that in the "quantity of money or currency" had been found one of the *most* effective causes of changes of price. Mr. Colwell's work was published in 1859, since which date so much light has been thrown on the subject as to make it serious cause for regret that his other engagements, and his failing health, should have prevented a re-examination of the case by aid of recent facts, all of which have tended to prove conclusively the accuracy of the views presented in the very instructive volume to which reference has now been made.

A word more and I shall have done. Of all the men with whom I have at any time been associated there has been none in whom the high-minded gentleman, the enlightened economist, the active and earnest friend to those who stood in need of friendship, and the sincere Christian, have been more happily blended than in the one whose loss we all so much regret, and of whose life and works I here have made so brief, and, as I fear, so inadequate a presentation.

List of the Published Writings of Stephen Colwell.

1. Letter to the Pennsylvania Legislature on the removal of the Deposits from the United States Bank. 8vo. pp. 45. 1834.
2. The Poor and Poor Laws of Great Britain. Prince. Rev. Jan. 1841.
3. Review of McCulloch's British Empire. Prince. Rev. Jan. 1841.
4. The Smithsonian Bequest. Princeton Review, 1842.
5. Sweden, its Poor Laws and their bearing on Society. P. R. 1843.
6. In and Out of the County Prison. No date.
7. The Relative Position in our Industry of Foreign Commerce, Domestic Production, and Internal Trade. 8vo. pp. 50. 1850.
8. Memorial to Congress in relation to Tariff on Iron. 8vo. pp. 16. 1850.
9. New Themes for the Protestant Clergy, with Notes on the Literature of Charity. 12mo. pp. 384. 1851.
10. New Themes for the Protestant Clergy, with Notes on the Literature of Charity. Second Edition. 12mo. pp. 384. 1852.
11. Politics for American Christians. 8vo. 1852.
12. Money of Account. Merchants' Magazine. pp. 25. April, 1852.
13. Hints to a Layman. 12mo. 1853.
14. Position of Christianity in the United States, in its relations with Our Political System, and Religious Instruction in Public Schools. 8vo. pp. 175. No date.
15. Preface and Notes to The Race for Riches 12mo. pp. 54. 1853.
16. The South : Effects of Disunion on Slavery. 8vo. pp. 46. 1856.
17. Preliminary Essay and Notes to The National Political Economy of Frederick List. 8vo. pp. 67. 1856.
18. Money of Account. Bankers' Magazine. pp. 25. July, Aug. 1857.
19. The Ways and Means of Payment. 8vo. pp. 644. 1859.
20. Money, the Credit System, and Payments. Merchants' Mag. 1860.
21. The Five Cotton States and New York. 8vo. pp. 64. 1861.
22. Southern Wealth and Northern Profits. 8vo. pp. 31. 1861.
23. The Claims of Labor, and their precedence to the Claims of Free Trade. 8vo. pp. 52. 1861.
24. Gold, Banks, and Taxation. 8vo. pp. 68. 1864.
25. State and National System of Banks, the Expansion of the Currency, the Advance of Gold, and the Defects of the Internal Revenue Bill of June, 1864. 8vo. pp. —. 1864. [1866.
26. Upon High Prices and their relations with Currency and Taxation.
27.* Influence of the duplication of Taxes on American Industry. 1866.
28.* Relations of Foreign Trade to Domestic Industry and Internal Revenue. 1866.
29. Over-importation and Relief. 1866.
30.* Iron and Steel. 1866.
31.* Wool and Manufactures of Wool. 1866.
32. Financial Suggestions and Remarks. 8vo. pp. 19. 1867.

Reports made from the Revenue Commission :—Those marked with an asterisk published in the Reports of the Committee.

Observations on the distribution of certain Extinct Vertebrata in North Carolina.

By Edward D. Cope.

(*Read before the American Philosophical Society, November* 17, 1871).

Diodon L.

Diodon antiquus, Leidy. Proc. Acad. Nat. Sci.

Superior and inferior jaws from the Miocene. This fish was described from transported and much worn specimens from the Ashley River, South Carolina. The present specimens are unworn, and display the characters of the species. These are very much like those of the recent *D. filamentosus*. The species appears also to pertain to the horizon of the Miocene.

Belodon, Myr.

Teeth of both the smooth and fluted types were found by Prof. Kerr in Chatham Co., N. C. The latter (*B. carolinensis*, Emm.) appear also to occur in Wheatley's collection, from the Trias of Phœnixville, Penn. Three successive forms of the maxillary teeth of *B. priscus* are figured.

Thecachampsa, Cope.

Thecachampsa rugosa, Emmons.

Polyptychodon rugosus, Emmons, Geol. Surv. N. C.

Emmons' figure of this species is not distinguishable from a worn canine of a *Basilosaurus*, and as such I regarded it on a former occasion. An examination of a specimen received from Prof. Kerr, shows that its affinities are Crocodilian, and its structure similar to that of *Thecachampsa*, Cope. It is more strongly rugose-striate than in any of the known species, but is approached in rugosity by *Thecachampsa squankensis*, Marsh. The range of the genus is thus extended to N. Carolina.

Clepsysaurus, Lea.

Teeth of this genus are very rare, one only having been observed by Dr. Lea. Prof. Emmons believed that he had discovered two species in the Trias of North Carolina, *C. pennsylvanicus* and *C. leaii*. The greater part of the remains on which these were based I have shown to be Belodonts, but one tooth figured by Emmons, N. C. Geol. Surv., Pl. V. f. 3, may belong to this genus.

Prof. Kerr's collection contains two teeth which are identical with that associated with the *C. pennsylvanicus* by Lea, one of them nearly perfect, the other the basal portion only. They exhibit two minutely denticulated cutting edges, separated by one-third of the circumference. This third is nearly flat, the remaining portion being very convex. One cutting edge extends to the base of the crown, the other occupies only the distal two-thirds. The section of the tooth would be round at the base were it not for the projection of the cutting edge. The enamel is minutely striate, under the glass. The base of the larger tooth measures .75 of an inch in diameter. The figure of Emmons leaves something to be desired, as he

does not represent the long cutting edge of the crown. His descriptions of the tooth appear to refer to this genus. Kerr's specimens are conclusive as to the extent of this formidable genus of carnivorous Dinosauria to N. Carolina.

ZATOMUS, Cope.

This genus embraces reptiles whose teeth are described and figured by Prof. Emmons, American Geology, Pt. VI. p. 62, fig. 34. He found them associated with radiate osseous plates (probably dermal) which he found on one occasion in connection with the cranium of the supposed Labyrinthodont, *Dictyocephalus elegans*, Leidy. Both the plates and teeth are too large to be associated with the latter, and the teeth especially remind one of the *Dinosauria*. Emmons describes a tooth in the following language:

"It is compressed, curved, finely serrate posteriorly, which appears to point to the apex, when seen so as to bring into view a slight wrinkle or groove at the base of each tooth. Its enamel covers the whole crown, or all above the part implanted or inserted. The enamel is finely or minutely wrinkled, and at the posterior edge, at the junction of the plates at each side, a faint groove remains; and the serræ appear like a double row, but near the apex they entirely disappear; the convex or anterior edge is smooth.

"The tooth appears much like the tooth of a *Megalosaurus* in miniature, though it is less curved. I have found only two teeth of this kind; the smallest is half the size of the one figured." This size is 0m. 022 in length; diameter at base .012.

In the section given by Emmons, one side of this tooth is a little more convex than the others.

The affinities of this genus appear to be to *Teratosaurus* and *Lælaps*. From both of these, as well as from *Megalosaurus*, it differs in the absence of serration from the anterior margin, and in the groove in the posterior cutting edge dividing it into two appressed serrate edges which disappear near the apex. The species may be called *Zatomus sarcophagus*. Its size about equalled large specimens of the Southern Alligator.

HYPSIBEMA, Cope.

Char. gen. Proportions of limbs and feet much as in Hadrosaurus. The caudal vertebræ elongate and depressed, in the median part of the series.

The elongate depressed form of caudal vertebræ, distinguishes this genus from Hadrosaurus. The latter possesses elongate vertebræ near the extremity of the series, but anterior to this point, they are first subquadrate in profile, then proximally much narrowed. The form exhibited by the known species of this genus is more like that of Hylæosaurus Mant.

HYPSIBEMA CRASSICAUDA, Cope.

The remains on which this species is founded consists of the distal extremity of the right humerus, a portion of the shaft of the left tibia, a

portion of the fibula, the right internal metatarsus somewhat broken, and a caudal vertebra. There are other uncharacteristic fragments, and a piece which may be a dermal bone.

Associated with them are several coprolites of large animals.

These species indicate an animal of about the size of the Hadrosaurus foulkei, Leidy, and with a similar disproportion in the lengths of the limbs.

This is readily appreciated on comparison of the huge metatarsus with the light humerus. The medullary cavity of the tibia is large; that of the humerus small.

The portion of the humerus preserved is injured, and the condyles are worn. Its relation to that of H. foulkei is readily determined, and on comparison the following marked differences appear: The ridge connecting the external condyle with the shaft posteriorly is acute; it is rounded in H. foulkei. External distal face is flat or slightly concave; in H. foulkei somewhat rounded. It is at right angles to the plane of the anterior face, and forms with it rather less than a right angle; in H. foulkei this region is rounded. Distally, the shaft is much flattened in H. crassicauda.

Measurements.	*Lines.*
Antero-posterior diameter of shaft, just above condyles	20.5
Width external face distally	24.
" olecranar fossa	16.
" condyles, (estimated)	64.

The anterior face at over three inches above the condyles is slightly concave. About 4.5 inches above the articular face of the external condyle, the acute ridge dividing the posterior and external faces disappears, and the surface becomes regularly rounded.

The portion of the tibia is from the shaft of that of the left side, just below the superior antero-posterior expansion. Therefore, the inner face is the most extensive, and the posterior the least so. It differs from the same part in H. foulkei, in its less angularity, especially in the more rounded, and less defined posterior face.

The internal face narrows downwards, and while the greater diameter of the fragment above is antero-posterior, below it is diagonal, the anterior point being the inner.

Measurements.	*Lines.*
Antero-posterior diameter above	48.
Transverse " "	22.5
" " medullary cavity	20.5

The portion of the fibula is the distal, and resembles that of Hadrosaurus foulkei, in being slightly expanded near the extremity, and cylindric in the lower part of the shaft. In both genera and Ornithotarsus, Cope, the distal extermity of the fibula is less attenuated then in Iguanodon.

	Lines.
Transverse distal diameter	40.5
" five inches above	30.

The right internal metatarsus also bears considerable resemblance to H. foulkei. Its proximal extremity is much more convex in its inner outline than in that species. The inner proximal face is plane and longitudinally wrinkled. The proximal or tarsal articular face is concave anteriorly; its plane is at right angles to the axis of the shaft of the bone. It is strongly oblique in H. foulkei, and a rib-like prominence of the outer face crosses the latter obliquely and at right angles to the proximal extremity. No such rib exists in the present case, because the weight was supported by the shaft of the bone, directly and not obliquely as in Hadrosaurus. Thus the Hypsibemas walked more exactly on the toes than did the Hadrosauri.

The posterior margin is thinner, and as in H. foulkei, presents a rather small median protuberance. The distal condyle is broken away, but the twist of the distal portion of the shaft shows that it was directed away from the adjoining metatarsal, posteriorly.

Measurements.	*In.*	*Lines.*
Length from antero-superior to postero-inferior,	10	10
Extremity (inferior articular face worn away),		
Traverse diameter proximally	3	
" " medially	2	3.5
Antero-posterior diameter medially	3	6.

The diameters of the shaft are somewhat larger than in the H. foulkei given by Leidy.

The caudal vertebra is of large size and peculiar form. The centrum is considerably wider than deep, and considerably longer than wide. The posterior chevron articulations are small, and each is connected with each anterior by a strong rounded angulation. Between the latter the space is wide and slightly concave in transverse section, least so medially. A marked peculiarity is seen in the strong longitudinal ridge which divides the lateral surface of the vertebra into two nearly equal faces. The neural arch is elongate, the neural canal small: in section a short vertical ellipse. The articular face of the zygapophyses makes an angle of about thirty-five degrees to the perpendicular. The crest of the arch rises a half inch behind these into the very stout basis of the neural spine, the greater part of which, with the posterior zygapophyses, is broken off. The inclination of the base is about 65° to the vertical diameter of the bone, The articular faces are both slightly concave, as are the lateral faces which are separated by the lateral ridge.

	In.	*Lines.*
Length of centrum	4	6
" basis of neural arch	2	9
Width posterior articular face	4	

		In.	Lines.
Depth	" medially	2	8
"	" laterally	3	3
" basis neural spine			12
Transverse diameter neural canal behind			10
Width between latero-inferior ridges		1	9
" vertical face of zygapophyses			11

There is a slight rugose protuberance in the position of the diapophysis.

The peculiarities of this vertebra indicate most strikingly the generic distinctness of this great reptile from the Hadrosaurus. It is true it presents some similarity in form to the terminal caudals of that genus and if it could be referred to that portion of the series, would indicate merely another and larger species of Hadrosaurus. It differs in form from these vertebræ, in its depressed instead of compressed form, and its lateral angulation. That it belongs to a more anterior position in the tail is evident from the very large size of the basis of the neural spine, and general greater development of the neural arch and zygapophyses, and the trace of diapophyses. Further, it is over four times the size of the terminal caudals of H. foulkei, while the remaining elements do not indicate any such extraordinary dimensions. A position a little behind the middle of the series would relate well to the other proportions.

This is another of those remarkable forms which the reptilian type developed in past ages. That it was herbivorous, and relied less on its tail for support than Hadrosaurus, appears probable. Large caprolites of the character of those of herbivorous animals accompanied the bones. They resemble somewhat those of the hog; one has a diameter of 3.5 inches one way, and 2 inches the other; extremity broad, obtuse. The proprietor of the pit told the writer that he had more than once seen large "hoofs" "and wide toe-joints" taken out during the excavation.

This species is different from the Ornithotarsus immanis, Cope, and belongs to a different genus. The shaft of the tibia in the latter is filled with cancellous tissue; in the present animal it is entirely hollow.

From the marl pits of James King.

Hadrosaurus, Leidy.

Hadrosaurus tripos, Cope.

At a point about ten miles distant from the marl pit in which the Hypsibema was found, Prof. Kerr discovered a caudal vertebra of a colossal reptile, whose affinities are evidently near to the Hadrosaurus foulkei.

This vertebra is one of the distal, as evidenced by the entire absence of any trace of diapophysis, and its subquadrate longitudinal section, as well as by the small size of the neural arch and spine. At first sight it would appear to occupy a position between the thirtieth and thirty-sixth of the series; the former in H. foulkei has, however, rudiments of a diapophysis. Both its articular faces are distinctly biconcave. The large

size of the chevron articular face is as in the thirtieth, and the concavity of its lateral faces as in the twenty-sixth; in the thirty-sixth the sides are entirely plane. The round form of the neural canal, as well as lack of diapophysis, are points of resemblance to the thirty-sixth, but it is more than twice as long as that vertebra in the H. foulkei. In the thirtieth the neural canal is somewhat depressed and becomes more so as we advance towards the proximal part of the series. The small antero-posterior extent of the neural arch is much as in the thirtieth in H. foulkei, but the basis of the neural spine, which is broken off in this, as well as the odd species, is much more slight. It is so very thin and weak as to indicate either comparatively a slight development of the spine, or a very posterior position in the series. A weak lateral ridge marks the side of the centrum, which is below the middle line. It holds the same position in the thirty-sixth in H. foulkei, but is above the middle in the thirtieth and those anterior.

Measurements.	*In.*	*Lines,*
Depth centrum to summit chevron articulation...	5	
" from neural canal without chevron face...	4	
Greatest width " " " ...	4	9
Length centrum.....	4	3
" neurapophysis	2	6
Width between anterior zygopophyses.....	1	3
" of arch above.....	1	6
" neural canal.....		10
Depth "		10
" basis neural spine.....		5

This specimen was procured from the marl pit of W. J. Thompson, Sampson Co., N. Carolina.

A second and much smaller vertebra from the pit that furnished the remains of Hypsibema crassicauda, belonged to a third individual, and possibly to this species. Its proportions would point to a position near the end of the tail, and its form is less elongate and compressed than those in that position in H. foulkei. Its neural arch is not coössified. The extremities are slightly concave, the general form subquadrate.

	Lines.
Length of centrum.....	20.5
Diameter extremity, (vertical).....	18.
" " (transverse).....	21.5
" middle "	15.

The first named vertebra pertained to an immense species, perhaps double the Hadrosaurus foulkei, in weight and bulk, should the general proportions of the two have been at all similar. In that case the length of the femur would be sixty-two and a quarter inches.

It will remain for future discovery to determine whether the species is the same as the Ornithotarsus immanis.

PLATE I.—*Hypsibema crassicauda.*

1. Caudal Vertebra of Hadrosaurus tripos, side. 1a. Articular face.
2. do. young? a. end, b. below.
3. Eschrichtius polyporus, side. 3a. above.

PLATE II.—*Hypsibema crassicauda.*

1. Humerus, distal portion, from below. 1a. From end.
2. Tibia shaft, from the side; 2a. from end.
3. Caudal Vertebra.
4. Coprolite fragment.

PLATE III.—*Hadrosaurus tripos. Eschrichtius polyporus.*

1. Fibula, lower portion; a. proximal end of fragment.
2. Outer metatarsal, inner side; 2a. proximal end of do.

PLATE IV.—*Mesoteras kerrianus. Clepsysaurus pennsylvanicus. Thecachampsa rugosa. Polydectes biturgidus. Belodon priscus. Diodon antiquus.*

1. *Mesosteras kerrianus*, periotic bones. 1a. Interior view; 1b. end view.
2. *Polydectes biturgidus*, crown of tooth, side; 2a. inner view.
3. *Thecachampsa rugosa*, crown of tooth, inner view.
4. *Clepsysaurus*, tooth, inside view; 4a. posterior view; 4b. section base; 4c. do. near extremity; 4d. base of larger sp.
5. *Belodon? priscus*, anterior tooth; 5a. posterior view of another; 5b. lateral view of a posterior tooth; 5c. edge of do.
6. *Diodon antiquus*, upper jaw front; 6a. do. from below; 6b. lower jaw from front; 6c. do. from above.

Stated Meeting, December 1, 1871.

Present, ten members.

Dr. Emerson in the Chair.

A letter of acknowledgment (86) was received from the Society of Antiquaries, dated London, November 8.

Letters of envoy were received from the Pontifical Academy d. N. L., dated Rome, June 7, 1869; and from the Public Museum, at Buenos Ayres, dated July 12, 1871.

A letter was received from Mr. H. H. Leech, dated New York, Nov. 18, 1871, offering for sale the MSS. Fables of M. Lorin, of Paris.

Donations for the Library were announced, from the P. A. d. N. L. at Rome, the R. Institutes at Milan and Venice, the R. Observatories at Moncaliere and Turin, Signori Dorna, Biffi, Muoni, Buccellati, Ferraris, Gabba, Mussi and Denza; from the Public Museum at Buenos Ayres; the Editors of the Revue Politique, Old and New, the American Chemist, and from Yale College.

A photographic copy of the quasi coin described below, was presented to the Cabinet by Mr. Dubois.

An Obituary notice of Sir John F. W. Herschel, written by Mr. H. W. Field, of the Royal Mint, London, pursuant to appointment, was read by Mr. Patterson.

Obituary Notice of

SIR JOHN FREDERICK WILLIAM HERSCHEL, BART.,

BY MR. HENRY W. FIELD, OF LONDON.

Read before the American Philosophical Society, December 1, 1871.

It is the painful duty of our Society to record the loss we have sustained in our membership, and indeed we may well say, the loss to the world in general, by the decease of the illustrious Sir John F. W. Herschel, Bart.

His father, Sir William Herschel, came from Hanover to England, in 1759, as one of the Hanoverian Guards' Band; and was for some time the subject of disappointment and privation. He however became instructor to a regimental band, stationed in the North, and fortunately obtained an organist's appointment in Yorkshire, and subsequently at Bath. Here it was that his taste for astronomy became developed, and from whence his first papers, "Observations of the Periodical Star Mira Ceti" issued. They were read before the Royal Society, in London, on the 10th May, 1780.

In 1781, the results of his studies and speculations led to his great discovery of Uranus (specially interesting from its leading to the discovery of the remote planet Neptune) which placed him most prominent in Scientific rank, which standing he retained until his death in 1822, being then in his 84th year.

Mr. Herschel, our lamented member, (unlike his father who raised himself from the humble rank of a regimental musician) after being educated privately by a Mr. Rogers, at an early age entered St. John's College, Cambridge, where by his great success and taste for science he graduated B. A. in 1813. He came out in the Mathematical Tripos, Senior Wrangler; an honor which was further enhanced by his attainment of the Fir s Smith's Prize. That his year was what is called, in Cambridge, "a good year," is evident from the names of the distinguished men of whom he took precedence, such as the following:—Peacock, Dean of Ely; Fallows, late Astronomer Royal at the Cape; Romilly, late Registrar of the University; Amos, Mill, and other men of note, whose names adorn the Det partments of Science, Theology and Literature. It may be worth while to note the feeling which subsisted among his fellow collegians; Charles Babbage, the mathematician (lately deceased) who coveted the honor of of Senior Wranglership, but knowing the powers of his antagonist, Herschel, declined to appear in the Mathematical Tripos, choosing rather to be at the Head of the Poll.

On the 27 May, 1813, he was elected Fellow of the Royal Society, and became one of its most active members, receiving in 1821 the Copley medal.

At his father's death he pursued that branch of science called "Observing Astronomy," and about this time he conceived the desirability of forming a Special Society, and was most active in its foundation, the present "Royal Astronomical Society."

In 1831, King William, as a tribute to his great scientific services conferred on him the honor of knighthood.

Sir John Herschel's researches on the positions of Nebulæ and clusters of stars, took up many years of his life. Several of the results he published in conjunction with Mr. (after Sir James) South, for which a reward of a gold medal was presented to both Astronomers. Were it not for the sincere love of science, the toil of these proceedings from midnight to sunrise would not have taken place; for no one can tell the strain on the constitution, the severity of which is gleaned from his observations while discussing the double stars. He remarked:

"Should I be fortunate enough to bring this work to a conclusion, I shall then joyfully yield up a subject on which I have bestowed a large portion of my time, and expended much of my health and strength, to others who will, hereafter, by the aid of those masterpieces of workmanship, which modern art places at their disposal, pursue with comparative ease and convenience an inquiry which has presented to myself difficulties such as at one period had almost compelled me to abandon it, in despair."

In 1833, Sir John Herschel was awarded the Royal Medal of the Royal Society, for his paper "On the Investigation of the Orbits of Revolving Double Stars." The Duke of Sussex, President, gave the following graphic account of his labors:

"Sir John Herschel has devoted himself, as you well know, for many years at least, as much from filial piety as from inclination, to the examination of those remote regions of the universe into which his illustrious father first penetrated, and which he has transmitted to his son as a hereditary possession, with which the name of Herschel must be associated for all ages. He has subjected the whole sphere of the heavens within his observation, to a repeated and systematic scrutiny. He has determined the position and described the character of the most remarkable of the Nebulæ. He has observed and registered many thousand distances and angles of position of double stars, and has shown, from the comparison of his own with other observations, that many of them form systems, whose variations of position are subject to invariable laws. He has succeeded by a happy combination of graphical construction with numerical calculations, in determining the relative elements of the orbits which some of them describe round each other, and in forming tables of their motions; and he has thus demonstrated that the laws of gravitation, which are exhibited as it were, in miniature in our own planetary system, prevail also in the most distant regions of space; a memorable conclusion justly entitled by the generality of its character to be considered as forming an epoch in the history of Astronomy, and presenting one of the most magnificent examples of the simplicity and universality of those fundamental laws of nature, by which their great Author has shown that he is the same to-day and for ever, here and everywhere.

"That he was not a mere meditative Philosopher, but one of laborious research and of a practical turn, appears from the imposing catalogue of his written works, a few of which I may be pardoned for enumerating: 13

papers on Optics; 28 on Astronomy; 10, Pure Mathematics, on Geology; on Photography; on Chemistry; on Natural Philosophy.

"The Encyclopedia Britannica boasts of excellent articles on Light and Sound, and Meteorology, now published separately."

A Manual of Scientific Enquiry, published by the Admiralty.

The Philosophical Transactions contain many of his valuable researches, especially those read before the Royal Society, 19 Nov., 1863, which will ever show his energy and perseverance in spite of the infirmities of his advancing age. In fact, turn where you may, light, emanating from Sir John, seems to cast its beams on almost every department of Science.

It may not be out of place to give an extract from his work "Outlines of Astronomy," a book which fills the student's mind with enraptured interest in the marvels which he reveals in plain and perspicuous language; for example:

"There is no Science which, more than Astronomy, draws more largely on that intellectual liberality which is ready to adopt whatever is demonstrated, or concede whatever is rendered highly probable, however new and uncommon the points of view may be, in which objects the most familiar may thereby become placed. Almost all the conclusions stand in open and striking contradiction with those of superficial and vulgar observation, and with what appears to every one until he has understood and weighed the proofs to the contrary, the most positive evidence of his senses. Thus, the earth on which he stands, and which has served for ages as the unshaken foundation of the firmest structures, either of art or nature, is divested by the Astronomer, of its attribute of fixity; and conceived by him as turning swiftly on its centre, and at the same time moving onwards through space with great rapidity. The sun and the moon, which appear, to untaught eyes, round bodies of no very considerable size, become enlarged on his imagination into vast globes: the one approaching in magnitude to the earth itself; the other immensely surpassing it. The planets which appear only as stars, somewhat brighter than the rest, are to him spacious, elaborate and habitable worlds; several of them much greater and far more curiously furnished than the earth he inhabits, as there are also others less so; and the stars themselves, properly so-called, which to ordinary apprehension present only lucid sparks or brilliant atoms, are to him suns of various and transcendent glory, effulgent centres of life and light to myriads of unseen worlds. So that, when after dilating his thoughts to comprehend the grandeur of those ideas his calculations have called up, and exhausting his imagination and the powers of his language to devise similes and metaphors illustrative of the immensity of the scale on which his universe is constructed, he shrinks back to his native sphere; he finds it, in comparison, a mere point; so lost, even in the minute system to which it belongs, as to be invisible and unsuspected from some of its principal and remote members."

Without fatiguing the Society, I think the following paragraph on the study of Natural Philosophy, will be its own apology for insertion.

"Among the most remarkable of the celestial objects, are the revolving double stars, or stars which to the naked eye or to the inferior telescope appear single, but if examined with high magnifying powers are found to consist of two individuals placed almost close together, and which when carefully watched are (many of them) found to revolve in regular elliptic orbits about each other; and, so far as we have as yet been able to ascertain, to obey the same laws which regulate the planetary movements. There is nothing calculated to give a greater idea of the scale on which the siderial heavens are constructed than these beautiful systems. When we see such magnificent bodies united in pairs, undoubtedly by the same bond of mutual gravitation which holds together our own system, and sweeping over their enormous orbits in periods comprehending many centuries, we admit at once that they must be accomplishing ends in creation which will remain for ever unknown to man; and that we have here attained a point in Science where the human intellect is compelled to acknowledge its weakness, and to feel that no conception the wildest imagination can form, will bear the least comparison with the intrinsic greatness of the subject."

England was not the only spot from which he made his observations. He found it desirable to carry on his investigations at the Cape of Good Hope, and for this far off scene of inquiry he embarked with his family at Portsmouth, 13 Nov., 1833. The course he prescribed to himself seems to have been to restrict his labors almost, if not entirely, to Stellar Astronomy. Still he did not omit to make many careful observations of the Nebulæ of Orion, of the Milky Way and of other heavenly phenomena; making accurate drawings, which he subsequently published.

In May, 1837, an extraordinary spot appeared on the sun's disc, the marvel of which was much increased when Sir John published his calculation that the crater of this supposed volcano was sufficiently large to allow the globe of the earth to pass in leaving all around a margin of 1000 miles.

On his return to England, in 1838, after, as he states, enjoying much happiness, together with the pleasures of good society, his grateful country bestowed upon him the dignity of a Baronetcy.

At this time, Photography beginning to attract much public attention, Sir John turned his thoughts to this beautiful art, directing his inquiries chiefly to that point so important to Photographers, the chemical action of solar rays.

Of the value attached to Sir John's scientific attainments we have abundant evidence in the instances in which he was called upon to occupy the place of advisor and councilor. As member of the Board of Visitors of the "Royal Observatory," when he was appointed to receive the annual report of its working and efficiency, a member of the "Standard Commission" on the question of the introduction of the "Metric System of Weights and Measures;" for many years as one of the leading members of the Council of the Royal Society.

On the retirement of Davies Gilbert, this venerable Society of savans

nearly succeeded in compromising its title, by almost electing the plebeian philosopher to the dignity of President, in preference to the Royal patron of science and literature, the Duke of Sussex. So keen was the contest that the subject of our memoir lost it only by 8 votes in a meetting of 240 members. He was President of the Astronomical Society three times. In 1845, he presided at the British Association for the Advancement of Science at Cambridge. Many learned European societies, beside those of his own country, rejoiced to inscribe his name on their rolls; but to none of them will our American Philosophical Society yield in its admiration, of this great citizen of the Republic of Literature and Science, as evinced by the bestowal upon him of their diploma of membership. In 1842, he was elected Lord Rector of Marischal College, Aberdeen.

The last of his public official positions, previously to his retirement into the quietude of a country life at Collingwood, in Kent, was that of Master of the Mint, to which he was appointed December 16, 1850, and which he retained until Professor Graham's appointment, April 27, 1855. In this office Sir John was a worthy successor of the great Sir Isaac Newton, who filled that office in the reign of William III.

In subsequent times, the Mastership acquired a political character and was conferred generally on members of the Cabinet, which continued until what is known familiarly amongst Mint employés, the Revolution of '51, by which the old system of charters, indentures and contracts for the meltings and coinages, being considered antiquated, it was desired by the higher powers to abolish. Naturally, this move caused much alarm and dissatisfaction; the distastefulness of which was, however, greatly modified by the gentle and considerate manner in which Sir John exercised the authority entrusted to him.

The labor and anxiety inseparable from a reconstruction of so important an establishment, much impaired the health of the subject of this memoir. Still his mental vigor did not succumb to bodily infirmity, as daily he was at his post about 11 o'clock, rarely leaving till 5 or 6 p. m., when he might be seen walking out with his portfolio under his arm, filled with papers to consider and revise, as an evening amusement.

Among the many alterations made by Sir John, he framed and calculated tables for standarding the various qualities of gold and silver, which superseded those said to have been Sir Isaac Newton's.

He sanctioned the abandonment of "Trial Plates" (designated by Sir John "Fiducial Pieces") which had been prepared from time to time and used for centuries, and presumed to be mathematically of the due proportions of the pure noble metal, but not really so. In lieu of this practice Sir John directed the Queen's Assay Master to use his best endeavors to obviate the evil, so that no officer of a foreign mint should be able to question the conventional purity of our British coin as being other than for gold 916.6, and for silver 925.

In giving effect to the Master's wishes, the Queen's Assay Master worked out the important correction by preparing and introducing chem-

ically pure gold and silver, in place of the standard trial plates. The following extract from Sir John's correspondence may be appropriately introduced here.

"The almost mathematical coincidence of the result of the Pyx (about 30 millions) with the legal standard, is the best proof which can be adduced of the admirable system of working the assays."

As illustrative of the unfailing kindness of this great man towards friends, as well as towards those, who had had the happiness to serve under him, the writer may be pardoned for introducing some of his *last* utterances contained in a letter, penned only five weeks before his departure to those realms of Light and Truth, amidst the wonders of which, while in the flesh, he *loved* to live.

"I am suffering under an attack of Bronchitis, which has lasted me all the winter, so excessively severe that I can hardly hold the pen, which must excuse the brevity of this, and being now in my 80th year, I can hope for no relief. I shall retain, however, *to the last*, a pleasing recollection of aid and support I received from you during the period of my administration of the Mint, and I know you will believe me ever, my dear sir, yours, most truly,

To H. W. F. (Signed) J. F. W. HERSCHEL.

In his domestic circle, he could unbend to the capacity of the young, in whose amusements he joined with spirit, and considering his advanced years, with wonderful energy. It may be instanced that, only a few years back, the great astronomer condescended to enter cordially into the children's Christmas gambols, and played in the most animated manner the part of Sir George with the Dragon; habiting himself in a coat of mail, extemporized from various culinary articles. His impromptu dialogue with his son as "the Dragon," was said by the elders to be absurdly clever. "The Herschels do everything well" was a common way of speaking of the philosopher and his family; so here the Dragon was so life-like, though made only of brown paper with a scarlet cloth tongue, and the knight looked so doughty, that the tableau nearly sent one of the children into convulsions.

Sir John F. W. Herschel, Bart., K. H., D. C. L., &c., was born at Slough, near Windsor, 7 March, 1792. He married, in 1829, Margaret Brodie, daughter to the Rev. Dr. Alexander Stewart, by whom he had a family of three sons and nine daughters. One is married to General, the Hon. Alexander Gordon, uncle of the present Lord Aberdeen, and now heir presumptive to that title. His youngest son is an officer in the Royal Bengal Engineers. He is succeeded in the title by his son Mr. William James Herschel, of the Bengal Civil Service, who was born in 1833 and married in 1864, Anne Emma Haldane Hardcastle, daughter of the late Mr. Alfred Hardcastle, of Hatcham, Surrey.

Sir John died at his seat, Collingwood, Hawkhurst, Kent, on Thursday, the 11th May, 1871, at 10 o'clock A. M., being in his 80th year. He was buried in Westminster Abbey, on Tuesday, the 19th May. His re-

mains were followed by the Presidents and many members of the various learned societies of England, also by the chief men of science in London.

The well-known Dean Stanley officiated on the mournful occasion, and on the following Sunday delivered in the Abbey one of his beautiful characteristic sermons, which may be found *in extenso*, in the July number of "Good Words," p. 453 (a work to which he occasionally contributed some popular papers on the wonders of the Universe). The Dean took his text from the 14th and 15th verses of the 1st chapter of Genesis.

"And God said let there be lights in the firmament of the Heaven to divide the day from the night; and let them be for signs and for seasons and for days and years; and let them be for lights in the firmament of the heaven to give light upon the earth; and it was so."

Glancing at the private sentiments of Sir John, in these days, when there appears to be an increasing antagonism between science and revelation, it is refreshing to remember how frequently in his writings, and in conversation with some of his friends, strong indications are observable, that the lofty mind of him who was a master in the science of the starry heavens could penetrate into higher regions still, and forget the proud achievements of intellect and science, in the humility of the adoring Christian; a humility which also manifested itself towards man in countless acts of generous sympathy and consideration. Of him truly it may be said in the language of a poetical tribute to his memory, which has recently appeared in a periodical of the day ("Good Words").

> "Science and learning led *his* mind, in reverent awe above;
> To him the voices of the stars proclaim'd their Maker's love."

In the above sketch of the scientific, official and personal character of the departed, it will be sufficiently apparent that with numberless other associations of the learned and scientific, in the decease of Sir John Herschel, *our* Society has to deplore the loss of a member whose name adorned the catalogue.

Mr. Dubois offered the following paper upon a *quasi* Coin, of Copper, affirmed to have been found at a great depth, in Illinois.

The annual reports of the Treasurer and Publication Committee were read and referred.

Pending nominations 679 to 682, and new nomination 683 were read; and the meeting was adjourned.

On a quasi Coin reported found in a boring in Illinois.

Read before the American Philosophical Society, Dec. 1, 1871,

By Wm. E. Dubois.

In July last, a letter was received at the Smithsonian Institute, from Mr. Jacob W. Moffit, of Chillicothe, Peoria county, Illinois, enclosing the photograph of a medal or coin, with the following particulars in relation to it :

"In August 1870, I took a contract of sinking a tubular well for Mr. Peter Cline, in this county. I had two men employed to assist in the labor, who are cognizant of all the facts connected with the finding of the coin.

"The following are the several strata through which we passed. We used a common ground auger, three inch bore :

"Soil, 3 feet. Yellow clay, 10 ; blue clay, 44 ; clay, sand, and gravel 4 ; purple clay, 19 ; brown "hard pan," 10 ; green clay, 8½ ; vegetable mould, 2 ; yellow clay, 2½ ; yellow hard pan, 2 ; mixed clay, 20½.

"Here we brought up *the coin*, on the auger, from a depth of one hundred and twenty-five feet.

"It has been examined by gentlemen in Chicago and St. Louis, without any result in explaining the mystery of its origin or date. It is my desire that a further investigation be made. I can, if necessary, send affidavits of myself and other parties as to the truth of these statements."

[Signed] Jacob W. Moffit.

It may here be added, that the place is in a great prairie, near the centre of the State, and near the Illinois river ; about 80 miles east of the Mississippi river.

Professor Henry having repeatedly referred rare coins to me, took the same course on this occasion, giving leave to communicate the facts to this society, if it was thought proper.

An examination of the piece itself was necessary ; and in reply to my request the owner forwarded the same, with further details, to wit :

" In answer to your questions I must say, that very few wells or shafts in this region have attained a depth of more than 50 or 75 feet, except in the valleys, where occasionally we find a well, through sand and gravel drift, at the depth of 100 feet.

" The only token of civilization discovered at a similar depth, in this State, was taken from a shaft in Whiteside county, about 20 years ago. The workmen at the depth of 120 feet discovered a large copper ring or ferrule, similar to those used on ship spars at the present time. They also found something fashioned like a boat-hook.

" There are numerous instances of relics found at lesser depths. A spear-shaped hatchet, made of iron, was found imbedded in clay at 40 feet ; and stone pipes and pottery have been unearthed at depth varying from 10 to 50 feet in many localities.

" No rational estimate has ever been made of the rate of annual earthy deposit. Our prairie land seems to have been built up by a deposit from

waters whose current set in from the N. W., changing its course only when in contact with some (then) eminence now far below the surface. The soil is seldom over three feet in thickness, usually underlaid by a yellow hard-pan of two to three feet. Wood is quite common at all depths at which wells have been sunk in blue clay.

"Nothing has been found in any of the Western mounds (as far as I am informed) bearing any resemblance in form or character to this coin.

"On taking the coin from the auger, I washed the clay from it with water. It then presented no appearance of corrosion, bearing a dull red hue, such as is common to old copper. However, after a few minutes, exposure to the air, it began to blacken, and in a short time was encrusted with a dark green, gummy coat, which I allowed to harden, and then removed by friction."

Thus far from Mr. Moffit. I learn from another source, that Chillicothe is built upon an alluvium of the Illinois river, very sandy, loose, and easily washed away. The river thereabouts is widened into a lake, about one mile and a quarter wide, and twelve miles long. The French pioneers went through that region, about the close of the seventeenth century. Whether the ground on which Chillicothe stands, has been made by the river, to the depth of 125 feet, since the entrance of the whites, is a point on which the residents there, with or without geological instruction, cannot venture an opinion.

As to the facts as above stated, there is every reason to rely upon their accuracy. I have to add some remarks on the physical and artistical traits of the coin itself.

Properly speaking, it is not a *coin* or medal, since the marks upon it have not been produced by striking, but by engraving or etching; and they are sunken, or intaglio. It is of copper in good condition, in shape polygonal approaching to circular, about one and an eighth inch in diameter; somewhat pitted by corrosions, and with very rude figures and inscriptions on both sides. The central image on one side is that of a man, or a child; on the other are two animals, one of them like a wild cat, with conspicuous ears. The legends are plain enough, to any one who can read them; but being somewhere between Arabic and Phonographic, without being either, they are sufficiently puzzling. Happily we have members whose knowledge of paleography may throw some light. For myself, I have seen nothing like it.

As to the other artistic characters, the metal proves, by a delicate gauge, to be very uniform in thickness; more so than could be attained by the beating out of a hammer in savage hands. I therefore feel sure it has passed through a rolling-mill; and if the ancient Indians had such a contrivance, it must have been pre-historic.

There are other tokens of the machine shop. Any one can see that the piece has been shaped, not with much symmetry, with shears or chisel; and the sharp edge taken down with a file. Coins or medals were not thus finished in ancient times, but they were in the middle ages, and in

Spanish America down to about 150 years past. (Tapping the edge with a hammer, was also in use).

If the figures and characters were made with a tool, it must have been a very rude one, since a "flat-nosed" graver would have left a smooth trough, while here it is rough and granular. This would suggest the greater likelihood of *etching*, were it not inconceivable that so advanced an art should have been practiced long ago on the Western prairies. The mineral acids, used for such work, were nowhere known until about the fourteenth century; and in Illinois, while we might suppose *agua ardiente*, we cannot concede *aqua fortis*, longer ago than one century. On the whole, it has been worked out with a very crude instrument.

As to the condition of the piece, and the discolorations; it is well known that copper, exposed to the air, acquires a superficial sub-oxide or dioxide, which protects it from further destruction. Very many ancient copper coins have been turned up by the spade or plough, which with a little cleaning up, look as if just out of the mint. I herewith show a specimen of Tetricus, a Roman usurper of the purple, in France, about A. D. 270; entirely free from corrosion. I also show a more interesting piece, which with many others, was ploughed up in the southern part of England, about 30 years ago. They were all so encrusted as to be illegible, and the owner gave me a choice at haphazard. On removing the coat of mail, and leaving only the mixture of brown and black oxides, it turned out to be a coin of Carausius, who established himself as a Roman Emperor in Britain, A. D., 287; as long before William the Conqueror, as William was before Victoria. This piece is rare and in perfect order, and forms a part of the Mint collection.

Some ancient coins, especially those with a slight alloy of tin or calamine, making them bronze or brass, are beautifully coated and protected with the green carbonate, the same as that which formed on the Illinois piece before cleaning. I herewith show one of these patinated pieces, a coin of Augustus, also from the Mint Cabinet. They may have been in favorable hiding-places, such as cinerary urns, or columbaria.

All things considered, I cannot regard this Illinois piece as *ancient*, nor *old*, (observing the usual distinction); nor yet *recent;* because the "tooth of time" is plainly visible.

What the piece was made for, is a part of the inquiry. Not for current money, because it would take a long time to make a handful; more likely a work of amusement, possibly to exercise the antiquarians. But how it got into such a deep place, supposing it a *bona fide* discovery which I cannot call in question, is a very perplexing point, and I gladly hand over the explanation to any one willing to undertake it. Certainly it seems, in connection with the finding of the copper ring, and other articles of iron and wood, at considerable depths, to form an item in the study of the formation of the superficial strata in that interesting section of our country.

Since the foregoing was written, I am favored with the suggestions (in writing) of Professor Lesley. He suspects that if anything, it is an astrological amulet. There are upon it the signs of Pisces and Leo. The

figures, on the obverse and reverse faces correspond in the attitude of the left arm raised and flourishing a whip, or thunderbolt. He reads the date 1572, and says that no geologist can accept the statement that a piece of that age could be lying naturally at a depth of 125 feet, under an Illinois prairie. The piece was placed there as a practical joke, though not by the present owner; and is a modern fabrication; perhaps of the sixteenth century; possibly of Hispano-American, or French-American origin. It may have some connection with the journeys of the early French priests or their voyageurs.

I would only add, that those views are forcible, but yet they take imposture for granted, and in so doing, leave us in this dilemma; that a curious piece was made many years ago, and held for the purpose of trick, until a deep hole should be made, long afterwards, in which to bury it, and complete the deception. It is also very hard to believe, that an intelligent and experienced operator in this line would allow himself to be sported with by workmen, and take so much pains, far and near, to ascertain what kind of article he had found.

Mr. Lesley explained:

He considered the integrity, experience and vigilance of the well sinker no guarantee against the surreptitious insertion of the coin. It is impossible to prevent a practical joke of that sort when the jester is resolved to have it so. Experience furnishes a thousand proofs of this in our extensive oil regions, where all kinds of rubbish have been brought to the surface from considerable depths; nails, anthracite coal, California nuggets, "butter of antimony," Lake Superior Red hematite iron ore, &c.

It looks as if there is a good deal of this sort of thing going on in the west. The copper-ring and boat-hook "taken from a shaft at Whitside; at a depth of 120 feet," "the *iron* spear-shaped hatchet embedded in clay at 40 feet" mentioned in the paper, are subjects for the same incredulity. The only possible explanation, excluding an imputation of fraud, in the latter case, would presuppose the recent filling up of a hole in the river bed with clay, through which a piece of iron might slowly settle down.

The discovery of a circular stone fire-place, with embers, by Mr. Latrobe's party of engineers in a gravel cut for the road bed of the Baltimore and Ohio R. R., many years ago, at a depth of 50 or 60 feet beneath the surface, is a circumstance belonging to quite a different category.

In the present case we have an evident imitation of Mediterranean coins. But the central figures are unmistakably Red Indian in their character. It is either unique of its kind, or one of a very small class. The probabilities against a borehole striking such an object are simply infinity to one. The improbabilities of the coin being at or near the surface, and being worked out from the wall of the hole by the friction of the rods, is equally great. There is too much method in the arrangement of the elements of the legend to doubt that the maker had a definite idea to express. A compound oval symbol occupies the right edge on each face, and may have a phallic significance. But the two human figures on one

face seem rather to be in conflict than in conjunction. The head dress may represent hair, or may represent the Indian warrior's feather crest.

Professor Trego remarked that he had seen the once famous grave mound relic and the man "who discovered" and possessed it, and believed it to be fraudulent. He had no faith in such discoveries in the west.

Stated Meeting, December 15, 1871.

Present, twelve members.

Dr. Wood, President, in the chair.

Letters of acknowledgment were received from the Anthropological Institute of G. B. and Ireland, Nov. 24, 1871, (83, 84, 85, 86, and Trans., Part 1, 1870). The N. V. d. P. R. u. W. at Bonn, Feb. 5. 1871 (82, 83). The N. Ges. Emden., Sept. 21, 1871 (84, 85); and the Linnean Society at Bordeaux, July 12, 1870 (78, 79).

Letters of envoy were received from the Societies at Bordeaux and Emden, Sept. 22, 1871; the Geographical Society at Vienna, Sept. 3, 1871; the American Legation at the Hague, Nov. 28, 1871; and the U. S. Naval Observatory, Dec. 5, 1871.

The death of Count Agenor Etienne de Gasparin, in June last, was announced by the Secretary.

Professor Cope communicated his views on the Method of Creation of Organic Forms, with illustrations on the blackboard.

Professor Cope added a Catalogue of Pythonomorpha found in the Cretaceous strata of Kansas.

Pending nominations 679 to 683, and new nominations 684 to 688 were read.

On motion of Mr. Price, the following resolution was adopted:

Resolved, That the Treasurer be authorized to pay to the Treasurer of the Fairmount Park Commissioners, three hundred dollars ($300) of the interest or rent lately received on the Michaux Legacy, to be applied towards the Michaux Grove and Michaux Nursery of Oaks in the Park, agreeably to the resolution of March 18th, 1870 (see page 312, Vol. XI., Proceedings A. P. S.)

And the meeting was then adjourned.

THE METHOD OF CREATION OF ORGANIC FORMS.

By Ed. D. Cope.

(*Read before the American Philosophical Society, December 15th*, 1871.)

Chapter I.—On the Law of Acceleration and Retardation. Nature of law of Natural selection. Two kinds of evidence. Illustration. Examples from cervidæ, helicidæ, insects and men.

Chapter II.—The Law of Repetitive Addition. Segment and cell repetition. Illustration from limbs and vertebral column. A, On segment addition; definitions. On repetition in bilateral and anteroposterior symmetry; in structure of compound teeth; in segments of articulata; limbs of Reptilia; brain of lamprey. B, On cell repetition; simple segment a repetition of cells; simple diverticulum the same. The cell theory; the nucleated cell. C, Synthesis of repetition. From unicellular to multicellular animals; simple repetition to compound repetition; *Actinia, Lepidosiren, Ichthyosaurus, Plesiosaurus, Tænia;* the heart; mammalian teeth. D, On growth force; relation to other forces; definition. E, Direction of repetition, its location, centrifugal and longitudinal; movements longitudinal. Inheritance; its relation to growth force.

Chapter III.—The Law of Use and Effort. Points to be investigated. A, On the location of growth force. Relation of effort to use. Rudimental characters. Examples of growth under influence of physical laws; Examples of colors under influence of light. Use and disuse of gills. Rattlesnake; horned animals. Teeth of ruminants. B, Change in amount of growth force. Local increase of growth force. Convoluted structures; brain, teeth, cotyledons. Absolute loss of growth force. Teeth and toes of Ruminants; incisors of Rodents.

Chapter IV.—On Grade Influence. A, On the nature of Grade influence or Bathmism. Definitions. In plants; in animals. Increase in time of Bathmism and growth force. Vital forces and vital influences. Thought force. Origin of Bathmism in time. B, Physiological origin of Bathmism. Function of nervous system in force conversion. Automatic and habitual movements. Effect on nervous system. C, The transmission of grade influence. Secretion in general. Spermatozoöids.

Chapter V.—Intelligent Selection. Development of intelligence. Stimuli to use. Compulsion, Choice; Bees, Food, Rattlesnake; Change of color; Mimetic analogy, Examples. Development of character.

In the present state of biological science, essays like the present can only be tentative in so far as they treat of the laws of evolution. Nevertheless the present time is preëminently one of generalization in this field, and properly so. Facts have been accumulating for a long period, and are now sufficiently numerous to yield important results, under proper classification and induction. Darwin led the way in this work, and the development hypothesis is regarded as demonstrated by most biologists. The discussion of the laws of its progress involves a multitude of subordinate hypotheses. In the following essay, these are arranged under five prominent heads, viz: 1, The law of Acceleration and Retardation; 2. The law of Repetitive Addition; 3. The law of Use and Effort; 4. The law of Grade Influence; 5. The law of Intelligent Selection. Of these, the first and second are regarded by the author as demonstrated, the third and fourth as only reduced to a partial demonstration, while the fifth is a consequence of the third, and stands or falls with it.

The discussion of this subject divides itself into two parts, viz: a consideration of the proof that evolution of organic types or descent with modification has taken place; and secondly, the investigation of the laws in accordance with which this development has progressed. As the latter involves the use of the evidence included in the former, I will not devote a special chapter to the proof for evolution.

The influences and forces which have operated to produce the type structures of the animal kingdom have been plainly of two kinds; 1. *Originative*, 2. *Directive*. The prime importance of the former is obvious; that the latter is only secondary in the order of time or succession, is evident from the fact that it controls the preservation or destruction of the results or creations of the first, and thus furnishes the bases of the exhibitions of the originative forces in the production of the successive generations of living beings.

Wallace and Darwin have propounded as the cause of modification in descent their law of natural selection. This law has been epitomized by Spencer as the "survival of the fittest." This neat expression no doubt covers the case, but it leaves the origin of the fittest entirely untouched. Darwin assumes a "tendency to variation" in nature, and it is plainly necessary to do this, in order that materials for the exercise of a selection should exist. Darwin and Wallace's law is, then, only restrictive, directive, conservative, or destructive of something already created. I propose then to seek for the originative laws by which these subjects are furnished—in other words, for the causes of the origin of the fittest.

It has seemed to the author so clear from the first as to require no demonstration, that Natural Selection includes no *actively* progressive principle whatever; that it must first wait for the development of variation, and then after securing the survival of the best, wait again for the best to project its own variations for selection. In the question as to whether the latter are any better or worse than the characters of the parent, natural selection in no wise concerns itself.

I. ON THE LAW OF ACCELERATION AND RETARDATION.

There are two modes of demonstration of evolution, both depending on direct observation. One of these has been successfully presented by Darwin. He has observed the origin of varieties in animals and plants, either in the domesticated or wild states, and has shown, what had been known to many, the lack of distinction in the grades of difference which separate varieties and species. But he has also pointed out that species (such, so far, as distinctness goes) have been derived from other species among domesticated animals, and he infers by induction that other species, whose origin has not been observed, have also descended from common parents. So far, I believe his induction to be justified; but when from this basis evolution of divisions defined by important structural characters, as genera, orders, classes, etc., is inferred, I believe that we do not know enough of the uniformity of nature's processes in the premises to enable us to regard this kind of proof as conclusive.

I therefore appeal to another mode of proving it, and one which covers the case of all the more really structural features of animals and plants.

It is well known that in both kingdoms, in a general way, the young stages of the more perfect types are represented or imitated with more or less exactitude by the adults of inferior ones. But a true identity of these adults with the various stages of the higher has, comparatively, rarely been observed. Let such a case be supposed.

In *A** we have four species whose growth attains a given point, a certain number of stages having been passed prior to its termination or maturity. In *B* we have another series of four (the number a matter of no importance), which, during the period of growth, cannot be distinguished by any common, *i. e.*, generic character, from the individuals of group *A*, but whose growth has only attained to a point short of that reached by those of group *A* at maturity. Here we have a parallelism, but no true evidence of descent. But if we now find a set of individuals belonging to one species, or still better, the individuals of a single brood, and therefore held to have had a common origin or parentage, which present differences among themselves of the character in question, we have gained a point. We know in this case that the individuals, *a*, have attained to the completeness of character presented by group *A*, while others, *b*, of the same parentage have only attained to the structure of those of group *B*. It is perfectly obvious that the individuals of the first part of the family have grown further, and, therefore, in one sense faster, than those of group *b*. If the parents were like the individuals of the more completely grown, then the offspring which did not attain that completeness may be said to have been *retarded* in their development. If, on the other hand, the parents were like those less fully grown, then the offspring which have added something, have been *accelerated* in their development.

I claim that a consideration of the uniformity of nature's processes, or inductive reasoning, requires me (however it may affect the minds of others) to believe that the groups of species, whose individuals I have

*A cut explaining this proportion will be found at the end of the essay.

never found to vary, but which differ in the same point as those in which I have observed the above variations, are also derived from common parents, and the more advanced have been *accelerated* or the less advanced *retarded*, as the case may have been with regard to the parents.

This is not an imaginary case, but a true representation of many which have come under observation. The developmental resemblances mentioned are universal in the animal, and probably in the vegetable kingdoms, approaching the exactitude above depicted in proportion to the near structural similarity of the species considered.

Example 1. It is well known that the *Cervidæ* of the Old World develop a basal snag of the antler, (see Cuvier, Ossemens Fossiles, and Gray, Cat. British Museum,) at the third year; a majority of those of the New World (genera Subulo, Cariacus) never develop it except in abnormal cases in the most vigorous maturity of the most northern Cariacus (*C. virginianus*), while the South American Subulo retains to adult age the simple horn or spike of the second year of all *Cervidæ*.

Among the higher *Cervidæ*, Rusa and Axis never assume characters beyond an equivalent of the fourth year of Cervus. In Dama the characters are, on the other hand, assumed more rapidly than in Cervus, its third year corresponding to the fourth of the latter, and the development in after years of a broad plate of bone, with points being substituted for the addition of the corresponding snags, thus commencing another series which terminates in the great fossil elk, Megacerus.

Returning to the American deer we have Blastocerus, whose antlers are identical with the fourth year of Cariacus. Corresponding with the Dama-Megacerus type of the Old World we have the moose (Alces) developing the same palmate horn on the basis of Cariacus (*i. e.*, without eye-snag.)

Example 2.—I select the following series, embracing the majority of the genera of the North American Helicidæ.*

1. Turns of spire very few; wide umbilicus; shell thin, with thin lips.....*Binneya.*
2. Turns few, but more; rest as above.....*Vitrina.*
3. Turns still more numerous; rest as above.....*Hyalina.*
4. As No. 3, but lip thickened inside.....*Hygromia.*
5. Coiled; *umbilicus closed;* lip thickened inside and out, *Tachea* and *Pomatia.*
6. Same, with a parietal tooth.....*Mesodon.*
7. Same, with parietal and two interior lip teeth.....*Isognomostoma.*

* * Recommencing at No. 4. All with *open umbilicus.*

5. As No. 4, but lip thickened in and out.....*Arionta.*
6. Same as No. 5, but with parietal tooth.....*Polymita.*
7. Same, with both parietal and lip teeth.....*Triodopsis.*

* See Tryon, Terrestrial Mollusca of the United States. Probably other (*e. g.* dental) characters distinguish some of these genera, but the above furnishes the history of one set of characters.

The successional relation of these genera may be represented in such a diagram as this:

In the history of the growth of the genera Isognomostoma and Triodopsis, the extreme forms of the two series, it is well known that at first the coils of the shell are extremely few, as in Binneya; and that like it, it is very thin and with a delicately thin edge; that the turns increase successively in number, as in Vitrina and Hyalina, and that finally the lip thickens as in Hygromia. Then the umbilicus may close as in Tachea, or (in Triodopsis) remain open as in Arionta. In either case a tooth is soon added on the body whorl (Polymita, Mesodon), and finally, the full maturity of the shell is seen in the added teeth of the inside of the lip margin. How many of the stages of the genera *Triodopsis* and *Mesodon* are identical with the genera of the series which represent them, I leave to more thorough conchologists, but that some now exhibit and all have once presented illustrations of the relation of exact parallelism, I cannot doubt.

Example 1.—An abundant race of the American deer, *Cariacus virginianus*, exists in the Adirondack region of New York, in which the development of the antlers never progresses beyond the spike stage of the second year. Therefore, some individuals of this species belong to Cariacus and some to Subulo.

Example 2.—A large part of the individuals of the common snail, *Mesodon albolabris*, never develop the tooth of the body-whorl, characteristic of the genus whose definition has to be modified to retain them.

Example 3.—Many individuals of *Triodopsis tridentata* from eastern North Carolina occur without the lip-teeth, characteristic of the genus *Triodopsis*. Hence these specimens, though of common origin with others of the species, must be referred to another genus.

Example 4.—Structural characters are known in many, if not all, species which are said to be "inconstant," being present or absent indifferently, thus being useless for definition. They may be rudimental when present or considerably developed. The presence or absence of wings in some species of insects may be cited; also the presence of generic characters in the male sex of many Coleoptera and their absence in the females. The characters of males, females, workers and soldiers in bees and ants may be added. All these facts belong to the same category as those cited among deer and mollusks and have a similar explanation.

Example 5.—It does not seem to be the law in "retardation" that parallelisms exhibited by the series in its rise to its highest point of development should retrace the steps by which it attained it, and that "exact

parallelisms" should be exhibited in a reversed order. Parallelisms, it is true, are exhibited; but so far as I have observed always "inexact," often in a high degree. A marked case of retardation occurs in the dental development of a number of persons who have come under my observation in the neighborhood of Philadelphia. It is not very uncommon to find persons in whom the third molars in both jaws are incomplete as to number, one, two, three, or all, being deficient. It is still more common for them to be incompletely covered by the enamel layer, and to become in consequence so worthless as to require early removal. I am acquainted with two families in which the absence of the exterior upper incisor on each side is common. In one of these the second and third generation have inherited it from the mother's side, and it now characterizes many of the children. The significance of this modification will be best understood by examining the dental structures of the *Quadrumana* in general. Commencing with the highest family and its abnormal dentition, we have:—

	Incisors.	Canines.	Premolars.	Molars.
Hominidæ, { Abnormal.	$\frac{1}{2}$	$\frac{1}{1}$	$\frac{2}{2}$	$\frac{2-2}{2-2}$
Hominidæ, { Normal.	$\frac{2}{2}$	$\frac{1}{1}$	$\frac{2}{2}$	$\frac{3}{3}$
Simiidæ	$\frac{2}{2}$	$\frac{1}{1}$	$\frac{2}{2}$	$\frac{3}{3}$
Cebidæ	$\frac{2}{2}$	$\frac{1}{1}$	$\frac{3}{3}$	$\frac{3}{3}$
Lemuridæ	$\frac{2}{3}$	$\frac{1}{1}$	$\frac{3-2}{3-3}$	$\frac{3}{3}$
Mammalia, Normal	$\frac{3}{3}$	$\frac{1}{1}$	$\frac{4}{4}$	$\frac{3}{3}$

In this table we see a decline in the number of teeth of the higher groups. Thus, the premolars are one less than the normal number in the whole order, and they lose one in each jaw in the Old World apes, and man. The molars maintain the normal number throughout, but the third in both jaws is in the *Simiidæ* reduced by the loss of a fifth or odd tubercle, thus becoming four-lobed. In the upper jaw, this is first lost in the Semnopithecus; in the lower, in the next highest genus Cercopithecus. In Homo its appearance is "retarded," the interval between that event and the protrusion of the second molar—six to ten years—being relatively greater than in any genus of *Quadrumana*. Its absence is then the result of continued retardation, not of a new and adaptive suppression, and is of direct systematic zoological value.

In the incisors a reduction is also plainly visible, as we pass from the most completely furnished mammals to the genus Homo. One from the upper jaw is first lost, then in the *Cebidæ*, one from the lower also. The number remains the same through the *Simiidæ* and normal *Hominidæ*, but in the abnormal cases cited, the process of reduction is continued and another incisor from each side disappears. That this also is truly "retardation" is also evident from the fact, that the exterior incisor is the last developed, being delayed in ordinary growth a year later than those of the inner pair. The same retardation is seen in the quadrumane *Cheiromys* (the *Aye-aye*), and the whole order *Rodentia*. In the latter, the rare presence of the reduced second incisors, as in *Lepus*, shows a less de-

gree of this modification. This retardation is also of systematic importance, and, should either of the characters described be constant in any of the species of the genus *Homo*, would at once entitle it to new generic rank. The very frequent absence of the posterior molars (wisdom teeth) has been recently found to characterize a race in India. Should this peculiarity prove constant, this race would with propriety be referred to as a new genus of *Hominidæ*, as we have many cases of very similar species being referred to different genera. It is altogether probable that such will, at some future time be the condition of some race or races of men.*

I am now disposed to regard the above as the method of production, not only of generic but of all other, including specific characters. It would appear that by excessive acceleration or retardation, some of the characters of a series may be skipped, but observations are not conclusive on this point, since very close examination is necessary for the appreciation of very transitory embryonic conditions.

II. ON THE LAW OF REPETITIVE ADDITION.

The origin of new structures which distinguish one generation from those which have preceded it, I have stated to take place under the law of *acceleration*. As growth (creation) of parts usually ceases with maturity, it is entirely plain that the process of acceleration is limited to the period of infancy and youth in all animals. It is also plain that the question of growth is one of nutrition, or of the construction of organs and tissues out of protoplasm.

The construction of the animal types may be referred to two kinds of increase—the addition of identical segments and the addition of identical cells. The first is probably to be referred to the last, but the laws which give rise to it cannot now be explained. Certain it is that segmentation is not only produced by addition of identical parts, but also by subdivision of a homogeneous part. In reducing the vertebrate or most complex animal to its simplest expression, we find that all its specialized parts are but modifications of the segment, either simply or as sub-segments of compound but identical segments. Gegenbaur has pointed out that the most complex limb with hand or foot, is constructed, first, of a single longitudinal series of identical segments, from each of which a similar segment diverges, the whole forming parallel series, not only in the oblique transverse, but generally in the longitudinal sense. Thus, the limb of the Lepidosiren represents the simple type, that of the Ichthyosaurus a modification. In the latter, the first segment only (femur or humerus) is specialized, the other pieces being undistinguishable. In the Plesiosaurian paddle the separate parts are distinguished; the ulna and radius well marked, the carpal pieces hexagonal, the phalanges defined, etc.

As regards the whole skeleton the same position may be safely assumed. Though Huxley may reject Owen's theory of the vetebrate char-

*The preceding section is merely an abbreviation with new illustrations, of the propositions brought forward in the writers "Origin of Genera," 1868, where a considerable extension of the subject will be found.

acter of the segments of the brain case, because they are so very different from the segments in other parts of the column, the question rests entirely on the definition of a vertebra. If a vertebra be a segment of the skeleton, of course the brain case is composed of vertebræ; if not, then the cranium may be said to be formed of "sclerotomes," or some other name may be used. Certain it is, however, that the parts of the segments of the cranium may be now more or less completely parallelised or homologised with each other, and that as we descend the scale of vertebrated animals, the resemblance of these segments to vertebræ increases, and the constituent segments of each become more similar. In the types Amphioxus, etc., where the greatest resemblance is seen, segmentation of either is incomplete, for they retain the original cartilaginous basis. Other animals which present cavities or parts of a solid support are still more easily reduced to a simple basis of segments, arranged either longitudinally (worm) or centrifugally (star-fish, etc.)

DEFINITIONS.

α The succession of construction of parts of a complex, was originally a succession of identical repetitions; and grade influence merely determined the number and location of such repetitions.

β Acceleration signifies addition to the number of those repetitions during the period preceding maturity, as compared with the preceding generation, and *retardation* signifies a reduction of the numbers of such repetitions during the same time.

γ The successive additions now characterizing the growth of the highest animals are not exact repetitions of segments at this time, because of influences brought to bear on cell nutrition during long periods. The nature of these influences is made the subject of another section.

In the endeavor to prove these positions, I will produce evidence, first, that some simpler animals grow according to the principle of modified repetitive addition, and that traces of it are to be observed in the most complex; second, that every addition to structure which has resulted in the complexity of the higher animals, was originally a repetition of a preexistent structure.

Detailed explanations of the law of repetitive addition are attempted in the following pages, under two heads, segment repetition, and cell repetition.

A. On Segment Repetition.

This is everywhere seen in the construction of animals and plants Double bilateral symmetry may serve as one example of repetition in growth.

a Bilateral symmetry. Anatomists have little difficulty in determining the bilateral symmetry in most animals; that is, the homologies of the parts on opposite sides of the median line. It might be almost asserted that it was a necessity of organization, but when we observe the growth of many plants, we are undeceived. And though bilateral symmetry in the *Cœlenterata* and many *Articulata* is perfect, yet in higher animals it

is more or less departed from. In the Vertebrata the *Amphioxus* is almost completely bilaterally symmetrical. In the fishes, the digestive system is the only one which does not conform to it; while in the birds the reproductive system is atrophied on one side. In the serpents the respiratory and part of the circulatory are similarly modified; and in the mammalia the digestive and circulatory systems have both become unsymmetrical; and the cranium even in the cetacea.

If evolution be true, the unsymmetrical forms have descended from the symmetrical, and the asymmetry being thus not inherited, is the result of laws which have interfered with the original tendency to bilateral repetition.

Many cases of bilaterally symmetrical diseases have been enumerated by physiologists, and I will select as an example one which has come under my observation. They were those of two boys who had had that disease involving the mucodermal system called Varicella, while the crowns of the successional incisor teeth were still enclosed in the mucous capsules of the alveolar walls. The deposit of phosphate of lime forming their surfaces was interrupted by the disease of the tissue, and the result was a surface pitted, or sculptured intaglio fashion. The sculpture of the two incisors of the right side was precisely imitated by those of the left in reversed order, even in minute details, which were numerous, thus producing a result not displeasing to the eye. This has been observed on two distinct occasions some years apart.

Another interesting example of bilaterally symmetrical disease, is recorded in a paper on "a case of universal hyperostosis, etc.," by Drs. Mears, Keen, Allen and Pepper. * They describe the skeleton of a boy of fourteen which displayed an extraordinarly exostosed condition, the bones themselves remaining in the condition known as osteoporosis. They describe the uniform repetition of the abnormal growths of one side on the other in the following language, (p. 22).

"Comparing the two sides externally, not only is there no difference in the extent and character of the disease, but there is the most remarkable symmetry of the corresponding diseased bones, which may be traced even into details. The disease begins and ends on both sides at corresponding points, it changes in character from simple porosity to the growth of osteophytes at corresponding points; if, on one side, the posterior part of the bone is most diseased, the same is true of the other side; if the osteophyte growth is continuous or interrupted on one bone (fibula fig. 18), it is so on the opposite one; if one is unusually diseased at a tendinous or aponeurotic insertion, so is its mate; if a groove or a variation in color exist on the one side, the same will be found on the other side; even of single marked spiculæ of bone the same may be said, so that a description of one side will answer for both, minute differences being noted as they occur."

b. Antero-posterior symmetry.

That this is an absolute law of creation will be less readily admitted

* See Proceed. Amer. Philos. Soc. 1870, p. 19.

than in the case of double bilateral symmetry, since the exceptions appear to be so universal. Nevertheless, I believe it to be as much a part of the law of Repetitive nutrition as the other. The antero-posterior homologies even of the human skeleton have been largely demonstrated, but as usual, we must appeal to the lower forms for a clear view of it. In the rudimental skeletal axis we find such symmetry almost perfect in the *Amphioxus*, but in no other vertebrate. In limbs we have it clearly indicated in the Reptilian order *Ichthyopterygia*, and in the Piscine order *Dipnoi*, where the anterior and posterior are scarcely or not all distinguishable. In the scapular and pelvic arches we find it also approximated in the first-named orders.

In the nervous system it also exists approximately in the *Amphioxus*. It is not seen in any vertebrate, and in but few other animals, in the digestive system, but it appears to exist in some lower articulata in both the respiratory and circulatory systems.

c. As illustrations of exact repetition involving large portions of the organism the higher Polyps may be cited, which differ from the lower chiefly by the addition of similar septa and similar tentacles. Examples of repetition of nearly the whole organism, may be found in many Entozoa as *Taenia*, where the cephalic segment only differs from the others, the remainder or proglottides being alike. The most entire repetition of structure is seen in *Vibrio*, where the segments are all alike, there being none representing a head.

d. As an example in special details of structure, the segments of the lowest brain (that of the lamprey) are repetitions of the first one. The pelvic arch of *Ichthyosaurus* when first created, was a repetition of the scapular, and the hind limb, of the fore limb. The segments of the limbs of the *Dipnoi* are mere repetitions, the later created of the earlier. The special parts of the pes and manus of *Ichthyosaurus* are simply repetitive efforts of growth-force joined with a diminishing amount. The addition of a digit often distinguishing one genus of Salamanders or Saurians from another, is evidence of a similar repetitive effort. The low mammal *Ornithorhynchus*, possesses but a single tooth in each jaw; the simple teeth of armadillos and cetaceans, increasing as they have done from a single commencement as in the monotreme cited, present examples of repetitive acceleration of growth force.

e. Complication of a single element of repetition is accomplished apparently by a double repetition. This is best understood by the consideration of the transition from simple to complex teeth. In the cetaceans this occurs in the Squalodonts; the cylindric incisors are followed by flattened ones, then by others grooved on the fang, and then by two rooted, but never double-crowned teeth. This is the result of antero-posterior repetitive acceleration of the simple cylindric dental type of the ordinary toothed cetacean.

Another mode of dental complication is by lateral repetition. Thus, the heel of the sectorial tooth of a Carnivore is supported by a fang alongside of the usual posterior support of a premolar, and is the result of a repetitive effort of growth force in a transverse direction. More complex teeth, as the tubercular molars, merely exhibit an additional lateral repetition, and sometimes additional longitudinal ones. As is well known, the four tubercles of the human molar commence as similar separate knobs on the dental papilla.

The above are cited as examples to explain the meaning of the proposition. When fuller demonstration is desired a greater number might be given.

B. On Cell Repetition.

That each additional act of creation in growth was originally identical with one which preceded it, and therefore an *exact repetition* in its character and results, is proven by the following considerations.

It has been already determined by the study of homologies that all organs and parts of an organism can be referred to an original simple archetype.

The question then remains as to whether the first element or lowest term, of a given organized part is essentially a new structure, or whether it be a repetition of some previously existing one. It may be asserted that the simplest expressions which shall cover all organs, are the solid segments and the hollow sack and tube. For example, we have already noted that the ultimate element of the limb is the first segment of the single ray of Lepidosiren. Is this short cartilaginous cylinder (which probably represents the fore-limb of some undiscovered member of the Dipnoi), a result of the repetition of a pre-existent structural element? This is no doubt the case, for as will be shown beyond, cartilage, though the least cellular of all the tissues is formed originally by cell-repetition or division. Again, the ultimate lobules of the most complex gland are but repetitions of the diverticula of the simply branched, and each of the latter repetitions of the simple cul-de-sac, which has its origin in a convexity of an originally plane surface. This convexity is again the result of repetition of cells or cell-division, whereby their number is increased and the surface rendered convex.

We are thus in both the solid segment, and hollow sack, brought down to cell repetition. Thus it is with organs, as with entire animals, in which, following the line of simplification, we reach at last forms composed of cells only, (*Actinophrys, e. g.*) and then the unicellular, (*Amœba*).

If this be the origin of organs, the question whether repetitive growth has constructed tissues, remains for consideration.

In growth, each segment—and this term includes the parts of a complex whole or parts always undivided, (as the jaw of a whale or the sac-body of a mollusk)—is constructed, as is well known, by cell division. In the growing fœtus the first cell divides its nucleus and then its whole outline, and this process repeated millions of times produces, according to

the cell theory, all the tissues of the animal organism or their bases, from first to last. That the ultimate or histological elements of all organs are produced originally by repetitive growth of simple nucleated cells, with various modifications of exactitude of repetition in the more complex, is taught by the cell theory. The formation of some of the tissues is as follows:

First Change—Formation of simple nucleated cells from homogeneous protoplasm or the cytoblastema.

Second—Formation of new cells by division of nucleus and body of the old.

Third—Formation of tissues by multiplication of cells with or without addition of intercellular cytoblastema.

A. In connective tissue, by slight alteration of cells and addition of cytoblastema.

B. In blood, by addition of fluid cytoblastema (fibrin) to free cells (lymph corpuscles), which in higher animals (vertebrates) develop into blood-corpuscles by loss of membrane, and by cell development of nucleus.

C. In muscles, by simple confluence of cells end to end, and mingling of contents (Kölliker).

D. Of cartilage, by formation of cells in cytoblast which break up, their contents being added to cytoblast; this occuring several times, the result being an extensive cytoblast with few and small cells (Vogt). The process is here an attempt at development with only partial success, the result being a tissue of small vitality.

Even in repair-nutrition recourse is had to the nucleated cell. For Cohnheim first showed that if the cornea of a frog's eye be scarified, repair is immediately set on foot by the transportation thither of white or lymph or nucleated corpuscles from the neighboring lymph heart. This he ascertained by introducing aniline dye into the latter. Repeated experiments have shown that this is the history in great part of the construction of new tissue in the adult man.

Now, it is well known that the circulating fluid of the fœtus contains for a period only these nucleated cells as corpuscles, and that the lower vertebrates have a greater proportion of these corpuscles than the higher, whence probably the greater facility for repair or reconstruction of lost limbs or parts enjoyed by them. The invertebrates possess only nucleated blood corpuscles.

C. Synthesis of Repetition.

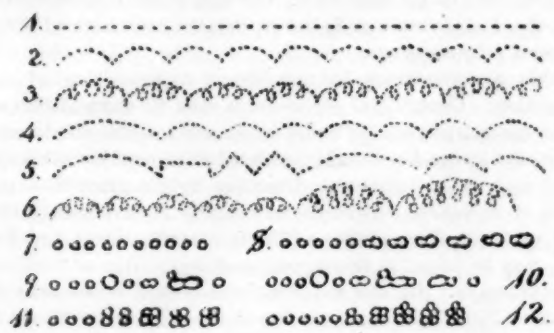
That growth force is capable of exhibiting great complexity of movement with increase in amount, will now be shown. That this quality of complication is one of its distinguishing features will appear plain.

The simplest forms of life, as stated by Hæckel, are simply homogeneous drops of protoplasm (*Protamoeba*). These only grow by ordinary accretion, and display a form of self division or reproduction which is the simplest possible; *i. e.*, the bisection of the mass by contraction at opposite points.

The next grade of animal type is represented by the nucleated cell. This is simple in *Amœba*, complex in *Actinophrys*, etc. With such forms as the latter, cell growth begins, and its development is accomplished by cell division. This is simple repetition of ultimate parts. In the growth of all higher types, we have nothing more than this, but following a law of *complex repetition*. Thus in the growth of the parts of an archetypal vertebral column, or an archetypal limb, we have the repetition of cell growth till the first segment is formed, when it ceases at that point, and repeats the process again, forming another segment like the first; repetition within repetition. So with the construction of muscular tissue; first, the nucleated cell repeated in a series, whose adjacent walls disappear, and whose cell contents flow together, thus forming a fibrilla; then a repetition of the same process forming a second fibrilla; and so on to the completion of thousands of them in fasciculi.

Let us then trace the series of repetitions and duplicated and still more complex repetitions, seen in following up animal forms from their archetypes.

In the simplest repetition of cell growth in a longitudinal direction we have *Vibrio;* in the centrifugal, *Actinophrys*. The former may be represented by a line of simple dots, thus :—Fig. 1.



In a complex repetition we rarely have the same degree of complication in each repeated part. We have it centrifugally almost perfect in a Cœlenterate (*Actinia*) and linearly in some of the lower Entozoa. An archetype of the latter kind might be represented thus :—Fig. 2. In a more complex form, as of the proglottides of *Tænia*, thus :—Fig. 3. The same might represent an archetypal vertebrate.

If now we attempt to express the complication of an organ by modified repetition of once identical parts, the history of extremities will serve us. Thus the limb of Lepidosiren which is composed of identical segments may be thus represented :—Fig. 2. Each longitudinal segment of the limb of Ichthyosaurus may be similarly represented with a modification, in size only, of the proximal or humerus; thus :—Fig. 4. But in *Plesio-*

saurus, an important series of changes of shape (but not in complexity) appears, which may be represented thus :—Fig. 5 ; the first being humerus, second ulna, third and fourth carpals (tarsals) the last phalanges, which are first specialized in this genus.

By far the most usual modification is however complication by duplicated and triplicated and still more highly multiplied repetition in some segments of the archetype, and its omission in other segments. Thus in in the *Tænia*, the cephalic segments are much modified, and the nature of its repetitions might be thus expressed :—Fig. 6 ; the simpler segments representing the body segment, the two complex, representing these of the head. In each, it will be observed, the complication is represented by loops of similar form, and each loop of dots which represent the cells in the first linear (fig. 1) arrangement.

A somewhat similar figure might represent the nature of the complication in the Myriapod. In the insect the additional complications of the thoracic segments would alter the diagram near the middle.

In the vertebrate cranium, a somewhat similar diagram might be used, except that the modification of the segments or vertebræ, as compared with the segments of the vertebral column, is not by repetition with modification of the parts of each segment, but rather by modification of the forms of the parts of the segments. The basi-cranial segments thus compare with the dorsal vertebræ as the segments of the limb of *Plesiosaurus* do to those of *Ichthyosaurus*.

The above considerations have reference to repetition of parts in a linear direction. Centrifugal repetition is seen in the addition of chambers to the heart, by the subdivision in the earliest stages into auricle and ventricle in the linear direction, considered in connection with the earlier division of each in the transverse direction, by the growth of partitions. This mode of repetitive addition is not readily represented by diagram.

A good example of repetitive addition in both linear and transverse direction, may be found in the successive complication of tooth structure seen in mammalia. In the dolphin, the dental series may be represented thus:—Fig. 7; in the squalodon thus:—Fig. 8; in the cat:—Fig. 9; in the dog:—Fig. 10 ; in man :—Fig. 11 ; in some insectivora :—Fig. 12.

The circles represented here, are each a simple cusp.

In conclusion, the directions of Repetitive growth may be tabulated as follows : The types to the left represent the original ; to the right, the derivative.

- Centrifugal.
  - Longitudin'l antero-posterior and bilateral.
    - More bilaterally symmetrical. — Only bilateral.
    - More antero-posteriorly. — Only antero-posterior.
  - Centrifugal.
    - In plane.
    - In globe.

D. On Growth Force.

From such examples as those that precede, but more especially from the last, it seems necessary to believe that there resides in organized matter, and in its most unmodified representative, the nucleated cell, an affection which displays itself in repetition. This phenomenon reduced to its lowest terms, may mean cell-division only, but the proof is only clear in cases of growth proper. This affection displays itself in very slow or more rapid repetitions,—cell-division in growth occurring rapidly, while its recurrences at rutting seasons in the development of horns, feathers, etc., are separated by long intervals of time. In acceleration these repetitions occur with increased rapidity, *i.e.*, in the adding of more structures during the same growth periods, while in low types its repetitions are few and therefore slow.

What is the relation of cell division to the forces of nature, and to which of them as a cause is it to be referred, if to any? The animal organism transfers solar heat and the chemism of the food (protoplasm) to correlated amounts of heat, motion, electricity, light (phosphorescence), and nerve force. But cell-division is an affection of protoplasm distinct from any of these; although addition to homogeneous lumps or parts of protoplasm (as in that lowest animal, *Protamœba* of Hæckel,) should prove to be an exhibition of mere molecular force, or attraction, cell-division is certainly something distinct. It looks like an exhibition of another force, which may be called *growth force*. It is correlated to the other forces, for its exhibitions cease unless the protoplasm exhibiting it be fed.

Professor Henry pointed out many years ago that this must be the case, basing his belief on the observed phenomena of growth in the potato, and in the egg. The starch of the potato weighs much more than the young shoot of cellulose, etc., into which it has been converted by growth activity, so that a portion of the substance of the tuber has evidently escaped in some other direction. This is shown to be carbonic acid gas and water, derived from the slow combustion of the starch, which in thus running down from the complex organic state, to the more simple inorganic compounds, evolves an amount of force precisely equal in amount to the chemical force (or chemism) requisite to bind together the elements in the more complex substance.*

Carpenter also states that in his opinion the growth of the Fungi is produced by a force liberated by the retrograde metamorphosis of their food, which is of an organic character, (*i. e.*, humus). This metamorphosis consists, as in the tuber, in the production of carbonic acid gas and water, and a force equivalent to the chemism which had bound them in the former complex union.† But in higher forms of vegetable life and in growth that follows germination, the plant must appropriate carbon from the carbonic acid of the atmosphere. The decomposition of the

* Agricultural Report of the Patent Office, 1857.

† Correlation of Physical and Vital Forces, 1864, (Quarterly Journal of Science.)

binary compound (which sets free its oxygen) liberates the chemical force which had previously maintained the compound, (or an equivalent force) which Henry regards as furnishing the growth force, which produces the plant. Carpenter derives but a portion of the force in this way, obtaining the greater part from the heat of the sun. To this source also he looks for the *growth force* employed in the construction of cold-blooded animals; while in warm-blooded animals, the retrograde metamorphosis or running down of the material (protoplasm) of the food, furnishes a requisite amount of heat. Whether growth force be derived from the chemism set free, direct, or through the mediation of heat, by conversion, among higher animals, is a question yet unsolved.

Growth force we may then regard as potential in organized tissue, and as energetic during growth. Our present knowledge only permits us to believe that other force is only converted into it under the influence of pre-existent life, but of the real cause of this conversion we are as ignorant as in the case of the physical forces.

In the animal organism, different tissues display different degrees of "vitality." The most vital display cell-organization and its derivative forms, while the least so, approach nearer to homogeneity. As organized tissue is the machine for converting vital forces, we may believe that less growth force is potential in cartilage than in muscle, for it is formed by a retrograde process, by which cells once formed are mostly burst, and the contents form the intercellular, nearly structureless mass characteristic of this tissue. Growth force must be here liberated in some other form, perhaps heat, to be again converted to other use.

The higher vitality we may believe to result from the greater perfection of the more complex *machine* as a force converter, as compared with the inefficiency of the more simple.

E. On the Direction of Repetition.

It has been already pointed out that *growth force* exhibits itself in cell or segment repetition. The forms in which it thus displays itself may be briefly considered. The approximate cause is treated of in the next chapter; but enough may be shown here to indicate that duplication and complex duplication is the law of growth force, and that therefore this process must always follow *an increase in amount* in any given locality.

The size of a part is then dependent on the amount of cell-division or growth force, which has given it origin, and the number and shape of segments is due to the same cause. The whole question, then, of the creation of animal and vegetable types is reduced to one of the *amount and location of growth force.*

Repetition is of two kinds, *centrifugal* and *longitudinal.* As an example of the former, the genus *Actinophys* has been cited, where the animal is composed of cells arranged equidistally around a common centre. The arrangement in this type may be discoidal or globular, providing no definite axis be discoverable. As an example of *longitudinal* repetition, *Vibrio*, and numerous cellular plants may be cited where the arrangement is in a single line.

In by far the greater number of animals these kinds of repetitive structure coexist. The *longitudinal* is however predominant in the *Vertebrata*, *Mollusca* and *Articulata*, while the *centrifugal* is greatly developed in the *Cœlenterata* and *Radiata*. In none but the simplest forms, are either of these modes to be found alone.

The *centrifugal* repetition or addition, more nearly resembles the mode of aggregation of atoms in inorganic or crystalline bodies, and hence may be regarded as the inferior manifestation. It implies that growth force in this case conforms to a law of polarity in exhibiting itself at equal distances from a centre,—which is allied to ordinary molecular force, and independent of the localizing influences of which higher organisms seem capable. In centrifugal animals, then, the latter evidently plays an inferior part. In Cœlenterates and Radiates, however, the body possesses a short longitudinal axis, in some (*Asterias*) very short, in others (*Holothuria*), more elongate. The amount of complication of centrifugal growth greatly exceeds the complication in a longitudinal direction in all of these animals except the *Holothurida*.

It is now important to observe that great numbers of centrifugal animals are sedentary or sessile; while the longitudinal are vagrant, moving from place to place. Many of the centrifugal animals which wander, do not do so in in the direction of their axis, but sideways (*Medusæ*). It is also proper to notice that not only the movements of the muscles, but also the direction taken by the food is in the long axis. It is therefore to be concluded that in longitudinal animals growth force has assumed a more truly animal type, and that this tendency has predominated over the polar or molecular tendency.

In most longitudinal animals, however, certain lateral portions, limbs, etc., extend on each side of the axis; and were the space marked by their extremities, and those of the axis, filled, we would have the outline of a centrifugal animal.

Before discussing the influences which have increased and located growth force, it will be necessary to point out the mode in which these influences must necessarily have effected growth. Acceleration is only possible during the period of growth in animals, and during that time most of them are removed from the influence of physical or biological causes, either through their hidden lives or incapacity for the energetic performance of life functions. These influences must, then, have operated on the parents, and become energetic in the growing fœtus of the next generation. However little we may understand this mysterious process, it is nevertheless a fact. Says Murphy, "There is no act which may not become habitual, and there is no habit that may not be inherited." Materialized, this may be rendered—there is no act which does not direct growth force, and therefore there is no determination of growth force which may not become habitual; there is, then, no habitual determination of growth force which may not be inherited; and, of course, in a growing fœtus becomes at once energetic in the production of new structure in the direction inherited, which is acceleration.

But if the forces converted into growth force are derived from without the animal organism, whence and what the agency by which the acceleration or retardation of the latter is inherited from the parent? A few suggestions only on this head can be made in the fourth section.

III. THE LAW OF USE AND EFFORT.

Up to this point we have followed paths more or less distinctly traced in the field of nature. The positions taken appear to me either to have been demonstrated or to have a great balance of probability in their favor. In the closing part of this paper I shall indulge in more of hypothesis than heretofore.

Since repetitive addition only produces identical results in archetypes, and each effort produces results more and more unlike its predecessor as structure becomes specialized; it becomes important to examine into the influences which have originally modified the repetitive efforts successively, producing structures more or less different in detail in the second generation from those of the parents, in acceleration, or the reverse, in retardation.

Going further back, the question arises, why a simple exhibition of repetition (*e. g.*, cell division) should be converted into a complex or duplicated repetition (*e. g.*, jointed ray). This it has already been stated, is one consequence of increased amount of the growth force.

We then seek explanation of the main question, as to what determines the location of this additional or new growth force. (Div. A.)

Lastly, why the total amount of this force should change in a given individual or part of an individual. (Div. B.)

A. On the Location of Growth Force.

What are the influences locating growth force? The only efficient ones with which we are acquainted, are, first, physical and chemical causes; second, use; and I would add a third, viz: effort. I leave the first, as not especially prominent in the economy of type growth among animals, and confine myself to the two following. The effects of use are well known. We cannot use a muscle without increasing its bulk; we cannot long use the teeth in mastication without inducing a renewed deposit of dentine within the pulp-cavity to meet the encroachments of attrition. The hands of the laborer are always larger than those of men of other pursuits. Pathology furnishes us with a host of hypertrophies, exostoses, etc., produced by excessive use, or necessity for increased means of performing excessive work. The tendency, then, induced by use in the parent, is to add segments or cells to the organ used. Use thus determines the locality of new repetitions of parts already existing, and determines an increase of growth force at the same time, by the increase of food always accompanying increase of work done, in every animal.

But supposing there be no part or organ to use. Such must have been the condition of every animal prior to the appearance of an additional digit or limb or other useful element. It appears to me that the cause of the determination of growth force is not merely the irritation of the part

or organ used by contact with the objects of its use. This would seem to be the remote cause of the deposit of dentine in the used tooth; in the thickening epidermis of the hand of the laborer; in the wandering of the lymph-cells to the scarified cornea of the frog in Cohnheim's experiment. You cannot rub the sclerotica of the eye without producing an expansion of the capillary arteries and corresponding increase in the amount of nutritive fluid. But the case may be different in the muscles and other organs (as the pigment cells of reptiles and fishes) which are under the control of the volition of the animal. Here, and in many other instances which might be cited, it cannot be asserted that the nutrition of use is not under the direct control of the will through the mediation of nerve force. Therefore I am disposed to believe that growth force may be, through the motive force of the animal, as readily determined to a locality where an executive organ does not exist, as to the first segment or cell of such an organ already commenced, and that therefore effort is, in the order of time, the first factor in acceleration.

Addition and subtraction of growth force in accordance with the modes pointed out below, account for the existence of many characters which are not adaptive in their nature.

Acceleration under the influence of effort accounts for the existence of rudiments of organs in process of development, while rudiments of organs in process of extinction are results of retardation, occasioned by absolute or complementary loss of growth force. Many other characters will follow, at a distance, the modifications resulting from the operation of these laws.

Examples of the Influence of Physical Causes.

This is nowhere better seen than in the case of coloration, which requires the light of the sun for its production. The most striking examples of this are seen in the colorless surface of animals inhabiting the recesses of caves, as the blind craw-fish and the *Amblyopsis*, etc. If evolution be true, these have descended from more highly colored progenitors. The flat fishes, also (*Pleuronectidæ*) as is known, swim on one side in adult age, but many of them are hatched symmetrical fishes, or nearly so, one eye rotating from one side to the other by a twisting of the cranial bones. It is thus probable that they have descended from symmetrical fishes, which were similarly colored on both sides. Now, the lower side is colorless, the upper retaining often brilliant hues. The influence of sunlight is thus as distinctly discoverable among animals as among plants, where it has been generally accepted as a principal of vegetable physiology.*

Examples of the Effects of Effort and Use.

a The Respiratory and Circulatory System of Vertebrates. It is well known that the succession of classes of Vertebrates is measured first by

*In this and similar cases, care must be taken not to misunderstand the writer by supposing him to mean that in *each generation separately* the peculiar coloration is the result of changed exposure to light. The evolutionist will understand that the effect of such influence increases with succeeding generations by the addition to inherited character, of the effect of immediate external cause.

their adaptation to aëration in water, and then by their successive departures from this type in connection with the faculty of breathing air. The same succession of structure is traversed by the embryos of the vertebrates, the number of stages passed being measured by the final status of the adult. This transition takes place in the Batrachia later in development than in any other class. Now, it is well known that the transition or metamorphosis may be delayed or encouraged by suppression of use of the branchial and encouragement of use of the pulmonary organs or the reverse.

The aquatic respiration of tadpoles may be indefinitely prolonged by preventing their access to the surface, and it is known that in nature the size or age of the larva at time of metamorphosis may vary much in the same species. If perennibranchiates (*Siren e. g.*) are deprived of their branchiæ, they will aërate blood by the lungs exclusively, and there is no reason to doubt that by use of these, and disuse of the branchiæ, aërial respiration might become the habit of the animal. It is also easy to perceive that geologic changes would bring about a necessity for precisely this change of habit. This occurred in the period of the coal measures, where large fresh water areas were desiccated, and it was precisely at this period that many air breathing Batrachians originated and had a great development.

β The rattle of the Rattlesnake.

Nearly all of the larger harmless snakes which live on the ground have a habit of throwing the end of the tail into violent vibrations when alarmed or excited, with the view of alarming a supposed enemy. Among *Coronelline* snakes, *Ophibolus triangulus* possesses it; among the water snakes, *Tropidonotus sipedon*. In the typical Colubrine group the black snake, *Bascanium constrictor* is an example; *Pityophis sayi* also shakes the tail violently. The copperhead (*Ancistrodon contortrix*) and the moccasin (*A. piscivorus*) (fide Günther) have the habit in a marked degree. Among the rattlesnakes it is a means of both warning and defence, in connection with the rattle which they carry.

In the structure of the end of the tail of harmless snakes, we see a trace of the first button of the rattle in a horny cap that covers the terminal vertebræ.

In the venomous genera, it is conspicuous in *Lachesis* especially, reaching a considerable length and having a lateral groove. In the plate-headed rattlesnakes (*Crotalus*) this corneous cap is inflated into a button with lateral groove, and in some of them possesses only one or two buttons or joints. In the perfected rattlesnakes (*Caudisona*) not only are the segments numerous and inflated, but a number of the terminal caudal vertebræ are greatly enlarged vertically, and coössified into a mass.* This is important from the fact that the rattlesnakes are the most specialized of all snakes, standing at the head of the order, and as such, on the principal of *acceleration* present the greatest amount of *grade nutrition*.

Now it appears to me, that the constant habit of violent vibration in a

*See good figures of this structure in Zeitschr. f. Wissensch. Zoologie, VIII, Tab. 12.

part, tends to determine an increased amount of nutritive fluid to it, in other words to localize growth nutrition, and when this has attained complex repetition or grade nutrition, to result in new grade structure. (The segments of the rattle being nearly all alike, it is a case of simple repetition.) This view appears to be as reasonable as that generally entertained with regard to the cause of spavin in the horse's leg. Here, owing to excessive use, exostoses appear on the bones surrounding the tibio-tarsal articulation. As to the reason of the structure in question not appearing in forms lower in the scale than the rattlesnake, it is explained below, if the law of accumulation of grade nutrition be true. (See sec. B.) This is, that repetition (or acceleration) is only possible where the animal has an excess of growth force at its disposal, or can abstract it from some portion which is unused or useless.

γ *On horns.* The possession of horns on the posterior part of the cranium, as defenses against enemies is a character found in many distinct types of animals. (Herbivora have no (dental) weapons and need horns). It is seen in the *Batrachia Stegocephala* in the extinct genus *Ceraterpeton;* among *Anura* it is approached by *Triprion* and *Hemiphractus.* Among Reptilia it is well marked in *Phrynosoma*, a Lacertilian genus. In *Mammalia* the *Artiodactyla Ruminantia* are the horned animals of the order. We have opportunities of observing the habits of these representatives of the Frogs, the Lizards and the Mammals.

In the first case, any one who has kept ordinary toads and tree toads in confinement, is aware that when attacked and unable to escape, they defend themselves by presenting the top of the head forwards and using it as a shield. Now I have already pointed out* that in both toads, tree toads, and frogs, there are natural series of genera, measured by the degree of ossification of the superior cranial walls, the longest being that of the Hylidæ, which embraces six terms, viz: *Hylella, Hyla, Scytopis, Osteocephalus, Trachycephalus* and *Triprion.* The two last have the head thoroughly shielded, and *Triprion* has projecting angles which appear in some South American forms lately described by M. Espada, to be developed into short horns. That this excessive ossification is associated with the habit of protecting the whole body with the front, seems likely.

In the case of *Phrynosoma* we know that precisely the same habit is associated with the presence of the sharp horns; and that some genera without horns possess it also. *Phrynosoma* is an exceptionally sluggish genus in a family of most active forms, and must necessarily resort to this mode of defence more than they.

In the case of Ruminants, we also know that defence is accomplished by throwing the head down with the horns thrown forwards. But this is not confined to this group. That generalized suborder, the *Artiodactyla Ordinaria,* represented by the hog, which were no doubt the genetic predecessors of the Ruminants in time, also throw the head down in defence in the same way, having thus a manner totally distinct from that seen in

*Origin of Genera, 1868, p. 14.

the *Carnivora*. The latter show their *teeth* and often crouch preparatory to a leap.

These cases present so constant an association between habit and use, that admitting evolution, we are compelled to believe that the structure has given rise to the habit or the habit to the structure. In the former case, we have to suppose, with the author of natural selection, that among the many spontaneous variations, rudimental horns occasionally appeared, and that their possessors being thus favored in the struggle for existence, were preserved and multiplied; while those not favored, dwindled and were ultimately nearly all extirpated or starved. The question of origin is here left to chance, and Alfred Bennett has made a mathematical estimate of the chances of any particular profitable variation occurring among the great number of possibilities of the case. This has shown the chance to be so excessively small as to amount in most cases to a great improbability.

If we turn to the probabilities of such structure having arisen through the selection of that mode of defence by the animal, we find them greatly increased. The position occupied by the horns, in all the animals described, is that which is at once brought into contact with an enemy in conflict, and as sport among animals is a gentle imitation of conflict, the part would be constantly excited in sport as well. With an excess of growth nutrition, our knowledge of the effects of friction on the epidermis, and of excessive ligamentous strain and inflammation on bone (*e. g.*, spavin in horses) as well as of abnormal exostoses in general, would warrant us in the belief that the use of the angles of the parts in question in these animals, would result in a normal exostosis, of a simple kind in the frogs, or as horn cores in the Ruminantia. As to the sheathing of the cores in the *Bovidæ*, and nakedness in the *Cervidæ*, it is in curious relation to their habitat and to their habits. The epidermis and derm would of course share in the effects of friction. In the Bovidæ which dwell in treeless plains, or feed on the grasses in great part, the development of these coverings of the horn cores into a horny sheath, would naturally meet with no interruption. In the case of the deer, which mostly live in forests or browse on trees, constant contact with the latter would prevent the healthy growth of the dermal covering, and it would be liable to injury or constant excoriation by the animals themselves on the branches of trees, etc. This we know to be the present habit of the deer as regards the dermal covering of the horns. I have elsewhere pointed out the similar connection between the dental structure and habitat among the oxen and the deer. The former eating the harder grasses, are provided against the consequent rapid attrition of the tooth, by a prismatic form, which allows of more prolonged growth and more rapid protrusion. The deer, in accordance with their foliage-eating habits, do not wear the crown of the tooth with such rapidity. Long continued protrusion is not so necessary, hence the teeth are more distinctly rooted and have a prominence or shoulder, distinguishing the body of the crown.

B. Change in Amount of Growth Force.

1. *Absolute increase of Growth Force.*—As every type has had its period of greatest development in numbers, size, and complication of structure, the present law indicates as an explanation, a culmination of the process of conversion of growth force from its energetic to its potential state in tissue. The cause is primarily the increased exercise of effort and use, which while effecting a conversion, increases the capacity of the organs by which further conversion is effected.

2. *Local increase of Growth Force.*—Examples of a local increase of this kind are probably to be seen in convoluted organs; as the convolutions of the brain in higher Mammalia; the convolutions of the enamel of the Labyrinthodont Batrachia; the same phenomenon in the cotyledons or plumule of some seeds. In these cases the superficial area of the parts is excessively developed, and the inclosing organs not being proportionately enlarged, a convolution necessary follows. In the first case, the skull; in the second, the alveolus; in the third case, the seed-envelope, restrain the expanse of the contained part, which would otherwise follow increase of growth force.

3. *Absolute loss of Growth Force.*—This will follow defective nutrition, produced by inability of the animal to obtain heat and food requisite to that end. This is supposed to be due (according to the view hereafter proposed) primarily to deficiency of intelligence, in failing to adapt habits to changed physical circumstances, and secondarily to the unfavorable influence of such changed circumstances. The extinction of highly specialized types, which has closed so many lines of animal types, will be accounted for by their less degree of plasticity and want of capacity for change under such changed circumstances. Such changes consist of modified topography and temperature, with irruptions of many new forms of life by migration. The less developed forms would be most likely to experience modification of structure under a new order of things, and palæontology teaches that the predecessors of the characteristic types of one period were of the less specialized forms of that which went before.

Thus is explained the fact that, in following out the line of succession of animal forms we have constantly to retrace our steps from specialized extremes, (as osseous fishes, tailless Batrachia, song birds, etc.), to more generalized or simple forms, in order to advance beyond.

4. *The complementary diminution* of growth nutrition follows the excess of the same in a new locality or organ, of necessity, if the whole amount of which an animal is capable, be, as I believe, fixed. In this way are explained the cases of retardation of character seen in most higher types. The discovery of truly complementary parts is a matter of nice observation and experiment. Perhaps the following cases may be correctly explained.

A complementary loss of growth force may be seen in absence of superior incisor teeth and digits in ruminating Mammalia, where excessive force is evidently expended in the development of horns, and com-

plication of stomach and digestive organs. The excess devoted to the latter region may account for the lack of teeth at its anterior orifice, the mouth; otherwise, there appears to be no reason why the ruminating animals should not have the superior incisors as well developed as in the odd toed (Perissodactyl) Ungulates, many of which graze and browse. The loss to the osseous system in the subtraction of digits may be made up in the development of horns and horn-cores, the horn sheath being perhaps the complement of the lost hoofs. It is not proposed to assert that similar parts or organs are necessarily and in all groups complementary to each other. The horse has the bones of the feet still further reduced than the ox, and is nevertheless without horns. The expenditure of the complementary growth force may be sought elsewhere in this animal. The lateral digits of the *Equidæ* are successively retarded in their growth, their reduction being marked in *Hippotherium*, the last of the three-toed horses; it is accompanied by an almost coincident acceleration in the growth nutrition of the middle toe, which thus appears to be complementary to them.

The superior incisors of the *Artiodactyla* disappear coincidentally with the appearance of horns, which always exist in the toothless division of the order, except in some very small antelopes (*Cephalophus*, etc.) where the whole amount of growth force is small. Possibly the superior incisors and horns are complementary here. The retardation in development of the teeth in the higher apes and men, as compared with the lower apes is coincident with the increase of number of brain convolutions. That this is not necessarily coincident with reduction of teeth in other groups is plainly proven by the rodents and *Chiromys* where the loss of many teeth is complementary to the great size of the incisors of the middle pair. But in man there is no complementary increase of other teeth, and the reduction is no doubt due to contraction of the jaws, which is complementary to increase in other parts of the cranium, in both apes and men.

I am confident that the origin and loss of many structures may be accounted for in this way, and the correlation of parts to each other be *measured* accurately.

Objection. The first one which arises is that which the author of the Vestiges of Creation made against Lamarck's theory of a similar kind, *i. e.* that by assuming that effort, use and physical causes have originated modifications of structure, we give the adaptive principle too much to do. I have made the same objection to the theory of natural selection. It is true that an application to a purpose is involved in the present theory of the "location of growth force;" but in point of fact, a large number of non-adaptive characters are accounted for by it. These are the rudimental and transitional ones which mark the successive steps preliminary to the completion of an adaptive structure; second, those produced by deficiency of growth force in less favored regions of the body, and third and fourth, phenomena consequent on general deficiency and excess of growth force.

And it may be said in conclusion that if the three principles, or if use especially, should be found to be inadequate to the service here demanded of them, it may be at least said that they or the last named, constitute the only controllers of growth force to any degree at all, with which we are acquainted.

IV. ON GRADE INFLUENCE.

The object of the present section is the attempt to discuss how the influence of effort and use on the parent is placed in a position to be inherited by the offspring.

A. Of the Nature of Grade Influence.

In the first place, it is necessary to note the definition and character of grade influence.

a. Growth force uninfluenced by grade influence simply adds tissue either (*a*) in enlarging size, or (*b*) in replacing waste. It does this by repeating the cell, by division, in localities which have already assumed their specific form. This form of growth force may persist throughout life, but with diminished energy in age.

β. Grade influence directs growth force in building up the tissues into organs, and constructs the parts of the body successively to completion, the result expressing the type or grade of the animal or plant. Its energy terminates with maturity, except in cases of periodical reproduction of sexual ornaments of the male (birds, deer), where it continues throughout life, appearing at regular intervals.

But it has occurred in acceleration that instead of a simple repetition of the ultimate histological element of an organism, in adding to its amount, it adds a completely organized part of the structure, as a tube, a phalange, a digit, a limb or an arch; an ocellus or a tooth. For instance, in the genus *Amblystoma*, one section possesses four phalanges on the longest digit; another section exhibits but three. In the species *A. mavortium*, some individuals have the small number of phalanges, but the majority possess the larger number. As all are of common parentage a whole phalange has been lost or added. The explanation of this phenomenon is essential to the comprehension of the *origin* of type structures.

*In plants, growth nutrition continues throughout life, but in the higher plants it is more active during the earlier years in perennial species, additions to size becoming less and less marked with increasing age. Grade nutrition also persists throughout life, but is chiefly active during a short period only of every year, or during flowering and fruiting. Not only in the production of the reproductive organs, but also in the yearly additions to other typical parts of the plant, grade-nutrition is active.

**In animals, growth nutrition is more active in the early stages of life, but is continued throughout in the lower divisions; in the highest, it is also continued throughout life, but there is a greater contrast between its results during youth, when nearly the whole size is attained, and during age, where the additions are much less.

Grade nutrition is, on the other hand, entirely confined to infancy and youth, except in those low animals which produce their reproductive organs periodically (some *Entozoa*, etc.), where it may be said to be in nearly the same condition as in plants.

γ While the amount of growth force, potential in adult living animals, has varied very irregularly throughout the animal kingdom, there being large and small, simple and complex, in every division, it would seem to have accumulated on the whole, with the rising scale of animal types. Thus the lower or *Protozoa* are the smallest; *Radiates* are next in size; *Molluscs* and *Articulates* reach nearly the same maximum, which exceeds that of the *Radiates*, and falls far below that of the *Vertebrates*. Among the last the mammalia have attained as large if not larger size than any of the other orders (*e. g.*, *Cetacea*). This is, however, not necessary to the history of evolution.

That an increased amount of grade growth force has been constantly rendered potential, during the advance of time is clear, if the preceding inferences be true. It is also evident that some individuals have accumulated it more rapidly than others, if all alike originated from the simplest forms known to us. Multitudes have remained in the earliest stages (*Protozoa*) of the whole series, or of their own special series (*Lingula*), forming "persistent types;" or taken directions which rendered them incapable of expansion beyond a certain point without exhaustion or death; for example, complicated types, as *Ammonitidæ*. The quadrumanous animal which was the progenitor of man, may thus be believed to have acquired a higher capacity of this accumulation than his cotemporaries.

Assuming the nucleated cell to be the ultimate element of organic tissue, there are two types of life in which grade influence has not appeared, viz.: unicellular animals and plants, and living forms composed of homogeneous protoplasm. In the latter neither grade influence nor animal growth force is potential; in the former, simple growth force only. It is therefore apparent that grade influence has been developed in the organism itself; perhaps this may have been, in the plant, through the modified influence of external physical causes; in the animal, if our inductions as to use and effort be true, under the influence of the activities of the parent, which determined a structural change either in itself or in its offspring. The possibilities of this origin are considered in the next section.

δ. The *Location of Growth Force* proceeds under the direction of what Professor Henry calls "Vital influence." With this author I discard the use of the term "Vital Force," what was originally understood by that term being a complex of distinct ideas. The *Vital forces* are (nerve force) *Neurism*, (growth force) *Bathmism*, and (thought force) *Phrenism*.* All

*The objection of President Barnard to thought being an exhibition of a force, is that "thought cannot be measured." This objection does not take into consideration the two-fold nature of thought. The *amount* of thought can most assuredly be measured, the *quality* of the thought, in one view of the case, cannot. That part which cannot be measured is that which determines the *Location of thought force*, which, as in the case of growth force, is an attribute of the vital or other principle.

of these are supposed to be correlated to the Physical Forces, but are under direction and control of the *Vital principle* which locates their action, etc., just as molecular or *atomic constitution* determines the locality and character of the physical forces. The laws of the vital principle and of atomic constitution also determine the nature of the conversion of one force into another. Now, since physical and vital forces are correlated and convertible, the close relationship of the two controlling principles becomes obvious, and suggestive of their identity.

Dr. Carpenter, in describing the correlation of physical and vital forces, defines the difference of organic species to be similar to that prevailing between different chemical bodies (the latter depending on different molecular and atomic constitution), which leads them "*to behave* differently" from each other under similar circumstances. This may be more fully expressed by saying that different species possess different capacities for the location of the conversion of the physical forces into growth-force. A "descent with modifications" contemplated by a process of evolution, signifies a progressive change in this capacity. *Acceleration* means an increase in this capacity; *retardation* a diminution of it. *Grade influence* means the influence which has produced this change of capacity.

Precisely what the change consists in is a mystery, but that it is material in its character is rendered more probable the more we examine it.

B. The Origin of Grade Influence.

Living protoplasm can convert heat and nutriment into growth force without the agency of the nervous system. This is proven by the nutrition of the *Protozoa* and *Cœlenterata* and from experiments on the muscles of frogs, etc. In the latter case, as is well known, the nerve may be divided, and the muscle retain its size if a current of electricity be passed through it, thus sustaining the nutrition. As the presence and structure of the nervous system is in relation to the specialization of animal structure in other respects, it is very probable that the nervous system is in *higher* animals the agent of the *location* of growth force. In the lowest it is not effected by any such means. As the nervous system is the instrument of the metaphysical peculiarities of the animal (emotions, choice, etc.), we may conclude that in the lower animals, location of growth force is influenced by necessity without choice; in the higher by necessity with choice.

The impulses derived from the nervous system, it is known, may be reflex or automatic in consequence of application of stimuli from without. They may become so also, after having been originated consciously or by effort of will. In the case of habits, frequent exercise of choice has so impressed the nervous system as to result in its repetition of effort, often in opposition to changed choice.

The influence of effort in muscular action on the nervous system appears to be, first, to enable it to convert heat to nerve force, and, then, to conduct nerve force to the involuntary muscles or those controlling circulation, where it is converted into motion, which thus controls nutri-

tion through circulation. The nervous system, like others, develops in capacity with use, hence probably nerve tissue converts heat into nerve force as muscular tissue converts heat into motion. In other words, by repetition, the capacity of the nervous system for this conversion of heat is known to increase. As the amount of heat converted is in proportion to the amount of appropriate nerve tissue (see above) it is evident that use and effort increase the amount of nerve tissue.

The phenomena of thought render the same modification of structure probable. Effort in the direction of thought is supposed to convert heat into thought force. Inasmuch as the more intelligent animals possess the highest development of cerebral hemispheres, it is highly probable that brain substance converts heat into growth force also, which produces tissue of its own kind precisely as muscle does.

As different parts of the nervous centres, subserve different purposes, the development of these parts must proceed approximately under the influence of special kinds of effort and use. Where, as in the adult, heat is converted into growth force in the tissues to a very limited extent, if the above principles be true, the conversion of heat by the nervous system into nerve growth force and tissue, is on the other hand, not terminated.

Capacity for effecting conversion of force is regarded, as above pointed out, as dependent on molecular constitution. Hence we conclude that change in that capacity on the part of the nervous system involves a molecular change in its constitution.

Now, it is apparent that if the nervous centres possessed the enlarged capacities for the conversion of heat into nerve force and thus of constantly controlling the circulation in special directions, in a growing or fœtal animal, tissue will be produced in the directions in question. For the heat converted into motion in the adult is in the fœtus in large part converted into growth-force.

Now, we know physical and metaphysical peculiarities of parents to be inherited by offspring, hence, no doubt, the nervous structure determinative of growth force is inherited. This will then control the localities of special conversion of heat, etc., (from the mother) into growth force, in accordance with the structure of the parent, and the more decidedly, as its own increase progresses.

The result will be *acceleration*, or construction of tissues and organs in excess of those of the parent, if the effort or use devoted to a nerve or organ be represented in the nerve centre of the parent by a greater amount of force-converting tissue, than is necessary when inherited in the fœtus for the construction (by conversion), of tissues and organs like those of the parent.

That this is a partial explanation of inheritance, is rendered probable from the fact that, the types of structure presented by the nervous centres, express the grade of the animals possessing them far more nearly than those of any other organ or set of organs. If the brain, like other organs, develops by intelligent use, it cannot be doubted that this relation of its development to grade is not accidental, but that grade structure is an expression of its capacities, physical and mental.

C. On the Transmission of Grade Influence.

How force potential in nerve structure is inherited through the reproductive elements is a great mystery. The following considerations relate to it.

1. Secretion is known to be conducted through the conversion of heat into growth force, probably through the intervention of nerve force.

2. In many secretions which possess strong chemical qualities, as gastric juice, bile, saliva, etc., the fluid is formed by a destruction of the cells representing the efforts of growth force, which is therefore no doubt converted into chemism or chemical force.

3. In the spermatozoöids, which are produced by a process of secretion, the cells are not destroyed, and thus growth force remains potential; they exhibit however lively motions, which may represent motive force derived from the nervous centre.

4. While in contact with the yolk of the ovum, so long as vitality lasts, the motion must be communicated to portions with which it is in contact, or converted into one of the forces from which it was derived (heat) or into another force (growth force). The growth force potential in the cell of the spermatozoöid, on its destruction, becomes converted into heat or other force. Thus may originate the growth force of the ovum, which, once commenced, is continued through the period of growth. The process might be compared to the application of fire to a piece of wood. The force conversion is communicated to other material than that first inflamed. The new fuel in the case of the embryo, is the protoplasm derived from the mother.

V. ON INTELLIGENT SELECTION.

As neither use nor effort can be ascribed to plants, and as we know that their life history is much more dependent on their surroundings, than is that of animals, we naturally look to the physical and chemical causes as having a prime influence in the origination of their type structures. Without greater familiarity with the subject, I will not attempt to say how far the various degrees of growth force possessed by parent plants, located under the influence of meteoric and other surroundings, and preserved, destroyed or restricted by natural selection, may account for the characters of their successors of the present period. But other agencies similar to use, that is, automatic movements, may be also introduced as an element in the argument. The movements of tendrils seeking for support may be here considered, and as Dr. Asa Gray has pointed out, have consequences similar to those of use in animals. When the tendril seizes a support, growth force is located at the point of contact, for the tendril increases considerably in thickness.

Among animals of the lowest grade, movement must be quite similar to those of plants, or automatic from the start, and not even at the beginning under the influence of will. Evidence of will is, however, soon seen in the determinate movements of many of the Protozoa in the seiz-

ing of food. With *will* necessarily appears a *power of choice*, however limited in its lowest exhibitions, by the lack of suggestive metaphysical qualities, or the fewness of alternatives of action presented by surrounding circumstances, to animals of low and simple organism. We can, however, believe that the presence of greater or less number of external facilities for action, characterize different situations on the earth's surface, as well as that greater and less metaphysical capacity for perceiving and taking advantage of them, must exist in different individuals of every species of animal, however low, which possesses consciousness and will. These qualities will, of course, influence effort and use to the advantage of the animal, or the reverse.

Effort and use have very various immediate stimuli to their exertion.

Use of a part by an animal is either compulsory or optional. In either case, the use may be followed by an increase of nutrition under the influence of reflex action or of direct volition.

A compulsory use would naturally occur in new situations which take place apart from the control of the animal, where no alternatives are presented. Such a case would arise in a submergence of land where land animals might be imprisoned on an island or in swamps surrounded by water, and compelled to assume a more or less aquatic life. Another case which has also probably often occurred, would be when the enemies of a species should so increase as to compel a large number of the latter to combat who had previously escaped it.

In these cases, the structure produced would be necessarily adaptive. But the effect would sometimes be to destroy or injure the animals (retard them) thus brought into new situations and compelled to an additional struggle for existence, as has, no doubt, been the case in geologic history.

Direct compulsion would also exist where alternatives should be presented by nature, but of which the animal would not be sufficiently intelligent to take advantage.

Most situations in the struggle for existence, afford alternatives, and the most intelligent individuals of a species will take advantage of those most beneficial. Nevertheless, it is scarcely conceivable that any change or increase of effort, or use, could take place apart from compulsion derived from the relation of external circumstances, as a more or less remote cause.

Preservation, with modifications, would most probably ensue when change of stimulus should occur gradually, though change of structure might occur abruptly, under the law of *expression points*.*

Choice is influence not only by *intelligence*, but by the *imagination* and by the *emotions*.

Intelligence is a conservative principle, and always will direct effort and use into lines which will be beneficial to its possessor. Here we have the source of the fittest—*i. e.*, addition of parts by increase and location of

* See origin of Genera, p. 38.

growth force, directed by the will—the will being under the influence of various kinds of compulsion in the lower, and intelligent option among higher animals.

Thus, intelligent choice taking advantage of the successive evolution of physical conditions, may be regarded as the *originator of the fittest*, while natural selection is the tribunal to which all the results of accelerated growth are submitted. This preserves or destroys them, and determines the new points of departure on which accelerated growth shall build.

The influences locating growth force, may be tabulated as follows:

Division.	*Influence.*				
Plants.	Physical and chemical.	+ ? ?			
Plants with mechanical movements; animals with indeterminate movements.	"	+ use			
Animals with determinate movements or will, but no intelligence	"	"	+ effort under compulsion.		
Animals with will and less intelligence.	"	"	"	"	+ choice.
Animals with more intelligence.	"	"	"	"	+ intelligent choice.

As examples of intelligent selection, the modified organisms of the varieties of bees and ants must be regarded as striking cases. Had all in the hive or hill been modified alike, all soldiers, neuters, etc., the origin of the structures might have been thought to be compulsory; but varied and adapted as the different forms are to the wants of a community, the influence of intelligence is too obvious to be denied. The structural results are obtained in this case by a shorter road than by inheritance.

The selection of food offers an opportunity for the exercise of intelligence, and the adoption of means for obtaining it, still greater ones. It is here that intelligent selection proves its supremacy as a guide of use, and consequently of structure, to all the other agencies here proposed. The preference for vegetable or for animal food determined by the choice of individual animals among the omnivores, which were, no doubt, according to the palæontological record the predecessors of our herbivores, and perhaps of carnivores also, must have determined their course of life and thus all their parts, into those totally distinct directions. The choice of food under ground, on the ground, or in the trees would necessarily direct the uses of organs in the appropriate directions respectively.

In the selection of means of defence a minor range of choice is presented. The choice must be limited to the highest capabilities of the animal, since in defence, these will, as a general thing, be put forth. This will, however, not be necessarily the case, but will depend in some measure on the intelligence of the animal, as we readily observe in the case of domesticated species.

In the case of the rattlesnake, already cited, the habit of rapid vibra-

tion of the tail, appears to me to be the result of choice, and not of compulsion. For the cobra, of India, for the same purpose, expands the anterior ribs, forming a hood, which is a very different habit. Here are two alternatives, from which choice might be made, and violent hissing is a third, which the species of the colubrine genus *Pityophis*, have adopted to some purpose. As to the benefit of the rattle, it no doubt protects the animal from all foes other than man; but is rather a disadvantage as regards the latter, being by a beautiful turn of events a protection to the higher animal.

On the principal of natural selection it might be supposed that the harmless snakes which imitate the Crotalus for the sake of defence were preserved; but if the above explanation of the origin of the habit in the latter be true, the second explanation is not valid.

The power of metachrosis, or of changing the color at will, by the expansion under nerve influence of special pigment cells, exists in most *Reptilia*, *Batrachia* and fishes. It is then easy to believe that free choice should, under certain circumstances, so habitually avoid one or another color as to result finally in a loss of the power to produce it.

Thus, it appears to be a fact, that not only are species of fishes which dwell in the mud, of darker hues than those that inhabit clear water, but that individuals of the same species differ in a similar manner in relation to their habitats, those that live in impure or muddy waters having darker tints than those of clear streams.

Land animals present equally abundant and remarkable imitations of the objects or substances on which they live. This is well known in insects and spiders, which look like sticks or leaves, or the flowers on which they feed. It is seen in reptiles, which in very many cases can voluntarily assume the hue of leaf, stone or bark, or have constantly the gray color of their native desert sands.

These cases are largely selective or optional in their origin, for though metachrosis is also induced by some external stimulus, as an enemy or a food animal, yet other means of escaping the one and procuring the other, are generally open.

These facts pave the way for a consideration of the phenomenon of mimetic analogy which, though well known to naturalists, may be illustrated by the following new facts:

On the plains of Kansas, there is a species of *Mutilla* whose abdomen and thorax are colored ochraceous or brown-yellow, above. A spider of the genus *Salticus* is equally abundant, and is almost precisely similar in the color of the upper surfaces, so much so as to deceive any but a most careful observer. The *Mutilla* being a well armed insect, and a severe stinger, there can be no doubt that the *Salticus* derives considerable immunity from enemies from its resemblance.

On the same plains, the *Caudisona confluenta*, or prairie rattlesnake abounds. It is an olive grey, with a series of transverse brown dorsal spots, and two rows of smaller lateral ones. The head exhibits a num-

ber of brown and white bands. The prairie *Heterodon*, (*H. nasicus*) possesses not only the same tints but the same pattern of coloration, and at a short distance cannot be distinguished from it.

In consequence, as one may justly say, this species is, with the rattlesnake, the most common serpent of the plains, as it shares, no doubt, in the protection which the armature of the *Caudisona* gives its possessor. This is in accordance with the views of Wallace and Bates.

A curious case occurred to me in four species of fishes, which I took in a small tributary of the Yadkin River, in Roane County, N. C. Among several others, there were varieties of the widely distributed species *Chaenobryttus gilli*, *Hypsilepis analostanus* and *Ptychostomus pidiensis*, (each representing a different family), which differ from the typical form of each in the same manner, viz : in having the back and upper part of the sides with longitudinal black lines, produced by a line along the middle of each scale. This peculiarity I have not observed in these species from any other locality. Until I had examined them I thought them new species.

The only other species presenting such marking in the Yadkin River, is the large perch, the *Roccus lineatus*. According to the theory of natural selection a resemblance to this well armed species might be of advantage to the much weaker species in question ; yet the same species co-exist in other rivers without presenting the same mimicry.

It is difficult not to urge the importance of the causes already regarded as efficient in the origination of structure, in the present branch of the subject also. We are especially disposed to call in use and effort here, after noticing how much more distinctly change of color is under the control of the animal, than change of shape. It must, however, be borne in mind that similar resemblances exist among plants ; though, as Prof. Dyer shows, a large majority of these cases occur in species of different floral regions. Thus in this case, as in those of structure already cited, we appeal first to physical laws in the lowest beings, but with the increasing interference of use, effort aud intelligence, as we rise in the scale. Thus it is that in the Vertebrates generally, the mimetic resemblances are found in species of the *same region*, where only an intelligent or emotional agency could be illustrated. If among animals as low as butterflies the influence of intelligence be denied, that of admiration for the beauty, or fear of the armature, of the predominant species imitated, would appear to be sufficient to account for the result. Admiration and fear are possessed by animals of very low organization, and with the instincts of hunger and reproduction, constitute the most intense metaphysical conditions of which they are capable. But our knowledge of this branch of the subject is less than it ought to be, for animals possess many mental attributes for which they get little credit.

It appears to be impossible to account for the highest illustrations of mimetic analogy in any other way, the supposition of Wallace that such forms must be spontaneously produced, and then preserved by natural

selection, being no explanation. It has been shown by Bennett that the chances of such modification arising out of the many possibilities are exceedingly small.

If the above positions be true, we have here also the theory of the development of intelligence and of other metaphysical traits. In accordance with it, each trait appropriates from the material world the means of perpetuating its exhibitions by constructing its instruments. These react by furnishing increased means of exercise of these qualities, which have thus grown to their full expression in man.

CRITIQUE.

1. *On the preceding essay.*—There will probably be found to be considerable resemblance and coincidence between the theory of Use and Effort, and the Lamarckian view of Development. The writer has never read Lamarck in French, nor seen a statement of his theory in English, except the very slight notices in the Origin of Species and Chambers' Encyclopædia, the latter subsequent to the first reading of this paper.

Darwin's only speculations as to the *origin* of new structures which are contained in his "Origin of Species" (Ed., 1860), so far as I can find, occur in the first and fifth chapters. In the first he says, discussing the variability of domesticated animals and plants, "I think we are driven to conclude that this greater variability is simply due to our domestic productions having been raised under conditions of life not so uniform as, and somewhat different from, those to which the parent species have been exposed under nature. There is also, I think, some probability in the view propounded by Andrew Knight that this variability may be partly connected with excess of food. * * * But I am strongly inclined to suspect that the most frequent cause of variability may be attributed to the male and female reproductive elements having been affected prior to the act of conception. * * Nothing is more easy than to tame an animal, and few things more difficult than to get it to breed freely under confinement, even in the many cases where the male and female unite," etc. Chapter V. repeats similar propositions but states that the effect of climate he believes to be small, but rather greater in plants than animals.

The view as to the impressibility of the reproductive element is taken up by Mivart, but the subject remains in the chaos of unshaped hypotheses.

2. *On the Origin of Genera.*—The memoir issued by the writer under the above name was chiefly devoted to the demonstration of the law of Acceleration and Retardation. A small portion was devoted to geographical and geological relations. It remains to correct two errors in the former portion of the book.

(1). It is there stated (p. 5) that the Law of Natural Selection of Darwin is as follows: "That the will of the animal applied to its body in the search for means of subsistence and protection from injuries, gradually produces those features which are evidently adaptive in their nature.

That in addition, a disposition to a general variation, on the part of the species, has been met by the greater or less adaptation of the results of such variation to the varying necessities of their respective situations. That the result of such conflict has been the extinction of those types that are not adapted to their immediate or changed conditions and the preservation of those that are."

It is unnecessary to state that the first sentence of the above does not express the theory of Darwin in any part or particular, while the two following do.

Further, it is stated (same page), "What we propose is, that of [generic characters] comparatively very few, in the whole range of animals and plants, are *adaptations* to external needs of forces, and that of specific characters a large proportion is of the same kind. How, then, could they owe their existence to a process regulated by adaptation?" Below, it is again said, "that while Natural Selection acts by the 'preservation of the fittest,' Acceleration and Retardation act without any reference to fitness at all; that instead of being controlled by fitness it is the controller of fitness."

Thus, from the existence of large numbers of non-adaptive characters I was induced to believe that an antagonism existed between the two laws. The present essay shews this to have been an error, and that by reconciling them, they become coördinate factors in producing the result. Thus "Acceleration and Retardation" is the "controller of fitness," because all adaptive structures are produced in accordance with it, and in no other way. The law of Intelligent Selection also prescribing fitness, removes it from the domain of physical or material necessity implied by Darwin's law of "Survival of the fittest." Adaptation therefore is the guide of change, though not the mechanically produced adaptation implied by natural selection. The disturbance of the balance of forces produced under its influence, leaves *growth force* to create primarily, the great number of unadaptive characters, which are simply *unfinished adaptive* ones, and secondarily, others occasioned by excess or loss of force in different directions.

The reconciliation of these laws and their complementary relations were perceived before the essay was completed, see in the recapitulation. Prop. II., p. 79.

(2.) Under the head of Heterology (p. 55), a number of groups are introduced as "Homologous" (as defined p. 54). Some of these I believe to be truly of this character, but some others are probably not so related, but are merely series of genera presenting similar structural peculiarities as consequences of the operation of identical laws. I would place under this head, and withdraw from the homologous class, the families of *Lacertilia Leptoglossa*, *Diploglossa* and *Typhlophthalmi*, those of the Old and New World *Quadrumana* and those of *Cephalopoda*.

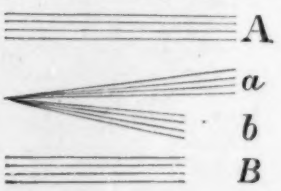


Fig. 13. (See p. 233.)

Catalogue of the PYTHONOMORPHA *found in the Cretaceous Strata of Kansas.*

BY E. D. COPE.

(*Read before the American Philosophical Society, December 17th*, 1871.)

The following brief review is prepared in consequence of the acquisition by the author of a considerable accession of material from the chalk of Western Kansas. Attention is confined to one order of Reptiles at present, owing to its predominant importance in the vertebrate fauna of that time and place, as is indicated by the great profusion of individual remains and specific forms. Although occurring in America wherever the Cretaceous formation appears, they are so far, more numerously represented in Kansas than elsewhere. Though not rare in New Jersey, crocodiles and tortoises outnumber them; but in Kansas, all other orders are subordinate to the *Pythonomorpha*. As is now well known since 1868* the seas of the American continent were the home of this order, while they were comparatively rare in those of Europe. In the latter country we have four species only determined by palaeontologists, viz:

Mosasaurus	2
Liodon	1
? Saurospondylus	1

In North America the species have been exactly determined from three regions, as follows:

Green Sand of New Jersey.

Mosasaurus	6
Baptosaurus	2
Clidastes	2
Liodon	4
(?) Diplotomodon	1
	15

Rotten Limestone, Alabama.

Mosasaurus	1
Holcodus	1
Liodon	3
Clidastes	2
	7

Chalk of Kansas.

Clidastes	3
Edestosaurus	4
Holcodus	4
Liodon	6
	17

* See Transactions Amer. Philo. Soc., Vol. XIV.

(*To be continued in No.* 88.)

The following Photographs have been received by the Society, for which the thanks of its Officers are tendered to the senders.

There are still many Members of the Society whose Cartes de Visite would find room in the Album, to beautify and complete the Record of its Membership.

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Bache, A. D.
Bache, Franklin
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Baird, S. F.
Bancker, C. N.
Barnes, Albert
Bancroft, John
Bancroft, Geo.
Bigelow, Jacob
Binney, Horace
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Böhtlingk, O.
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Casem Beg. A.
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Clymer, Geo.
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Coles, Ed.
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Coppée, W.
Crevecoeur, de
Cresson, J. C.
Cope, E. D.
Cook, G. H.
Chabas, F.
Darlington, W.
Dana, J. D.
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Davis, C. H.
Dawson, J. W.
Delesse, A.
Desor, E.
Dorn, C. A.
Dorr, B.
Dupont, S. F.
Durand, E.
Dewey, C.
Elwyn, A. L.
Emerson, G.
Encke, J. F.
Everett, E.
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Field, H. W.
Foulke, W. P.
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Graham, J. D.
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Graeff, F.
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Hayes, I.
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Henderson, A. A.
Hitchcock, E
Hill. Thomas
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Hartshorne, H.
Hodge, H. L.
Horn, G. H.
Hoffman, A. W.
Horsford, E. N.
Humboldt, A. de
Humphreys, A. A.
Hunt, T. S,
Hyrtl, J.
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James, J. F.
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Jäger, G.
Jenks, W.
Jarvis, E.
Julien, St.
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Lepsius, R
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Maximilian.
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Morgan, J.
Morlot, A.
Morse, S. F. B.
Norton, W. A.
Ord, Geo.
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Quincy, Jos.
Quetelet, A.
Rhoads, E.
Rand, B. H.
Röhrig, F. L. O.
Roberts, S. W.
Robinson, M.
Rokitansky, C.
Rushenberger, W.
Saxton, Jos.
Seidenstriker, O.
Schott, C. A.
Sharswood, Geo.
Sheafer, P. W.
Short, G. W.
Shurtleff, N. B.
Shumard, B. F.
Schintz, C.
Sandberger, D. F.
Silliman, B.
Smith, F. G.
Sparks, J.
Strong, W. B.
Strohmeyer, A.
Swift, H. G.
Totten, J. G.
Troyon, Fr.
Tunner, P.
Walter, P. T.
Wayland, Fr.
Torrey, John
Wood, G. B.
Wilson, T. B.
Wharton, Jos.
West. F.
Wetherill, C. M.
Whitney, J. D.
Whitney, W. D.
Wilcox, A.
Wilkes, Ch.
Wistar, C. J.
Winchell, A.
Zantedeschi, F.